FINAL

REMEDIAL INVESTIGATION REPORT

for the

FOSTER WHEELER ENERGY CORPORATION/CHURCH ROAD TCE SITE
MOUNTAIN TOP, PENNSYLVANIA

Pursuant to Section 9.1(d)(4) of the Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study, Docket No. CERC-03-2009-0061DC

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1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCA	1,2-dichloroethane
3DVA	3-Dimensional Visualization and Analysis
ACM	Asbestos-Containing Material
AGI	American Geosciences, Inc.
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
ASD	Active soil depressurization
AST	Aboveground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
BHTV	Borehole Televiewer
BOD	biological oxygen demand
BTAG	Biological Technical Assistance Group
CAL	Caliper Logging
CAO	Consent Agreement and Order
CCC	Criteria Continuous Concentrations
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
CMC	Criteria Maximum Concentrations
COD	chemical oxygen demand
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CT	Central Tendency
DGAR	Data Gap Analysis Report
DO	dissolved oxygen
DOC	dissolved organic carbon
EC	electric conductivity
ECD	electron capture detector

ECO-SSL	Ecological Soil Screening Level
EEQ	Ecological Evaluation Quotient
Eh	Oxidation Reduction Potential
ELCR	Excess Lifetime Cancer Risk
EPC	Exposure Point Concentration
EPIC	Environmental Photographic Interpretation Center
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FID	Flame Ionization Detector
FLC	Fluid Conductivity
FLUTe	Flexible Liner Underground Technologies
FOC	fraction organic carbon
FS	Feasibility Study
FSP	Field Sampling Plan
FWEC	Foster Wheeler Energy Corporation
GC	Gas Chromatograph
GETS	Groundwater extraction and treatment system
GFEE	Gannett Fleming Environmental Engineers
gpm	gallon per minute
GPR	ground penetrating radar
GPS	Global Positioning System
GRA	General Response Action
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Table
HI	Hazard Index
HPG	International, Inc.
HQ	Hazard Quotient
HVAC	heating, ventilation and air conditioning
IDW	Investigation Derived Waste
ILCR	Incremental Lifetime Cancer Risk
IRIS	Integrated Risk Information System
IRM	Interim Remedial Measure
IUR	Inhalation Unit Risk
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mgd	million gallons per day
MIP	membrane interface probe
MK	Morrison-Knudsen Company
MRL	Minimum Risk Level
MSC	Medium Specific Concentration

msl	mean sea level
MW	Monitoring Well
NAD	North American Datum
NAPL	Nonaqueous Phase Liquid
NAVD	North American Vertical Datum
NCP	National Contingency Plan
NG	Natural Gamma Logging
NOD	natural oxygen demand
NP	Neutron Porosity
NPL	National Priorities List
NWI	National Wetland Inventory
O&M	Operation and Maintenance
OU	Operable Unit
PA	Preliminary Assessment
PADEP	Pennsylvania Department of Environmental Protection
PADER	Pennsylvania Department of Environmental Resources
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	tetrachloroethene
PCSM	Preliminary Conceptual Site Model
PCU	Power Control Unit
PDBS	Passive Diffusion Bag Samplers
PE	Performance Evaluation
PEA	Potential Exposure Area
PID	Photoionization Detector
PLM	polarized light microscopy
PNDI	Pennsylvania Natural Diversity Inventory
PP	Priority Pollutant
ppb	parts per billion
ppbv	parts per billion by volume
PPRTV	Provisional Peer Reviewed Toxicity Value
PQO	Project Quality Objective
PRG	Preliminary Remediation Goal
PVC	Polyvinyl Chloride
Q3G	Quad Three Group
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RAP	Response Action Plan

RBP	Rapid Bioassessment Protocol
RCRA	Resource Conservation and Recovery Act
REAC	Response, Engineering and Analytical Contract
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RIR	Remedial Investigation Report
RL	Reporting Limit
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RQD	Rock Quality Designation
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SIA	Special Industrial Area
SIPs	Surrounding Industrial Properties
SLERA	Screening Level Ecological Risk Assessment
SOD	soil oxygen demand
SP	Single Point Resistivity
SQG	Sediment Quality Guideline
SRP	Site Remediation Program
SSLs	Soil Screening Levels
START	Superfund Technical Assessment and Response Team
SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
TAT	turnaround time
TBC	To Be Considered
TCE	trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TMP	Fluid Temperature
TOC	Total Organic Carbon
TSS	total suspended solids
Tt	Tetra Tech, Inc.
TtEC	Tetra Tech EC, Inc.
UCL	Upper Confidence Limit
ug/kg	micrograms per kilogram
ug/L	micrograms per liter
ugPb/dL	micrograms lead/deciliter
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency

USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
VI	Vapor Intrusion
VOC	Volatile Organic Compound
WABCO	Westinghouse Air Brake Company
Wabtec	Westinghouse Air Brake Technologies Corporation
WCC	Woodward Clyde Consultants
WQ	Water Quality
WWTP	wastewater treatment pond
WWTS	wastewater treatment system
μg/kg	micrograms per kilogram
μg/l	micrograms per liter

EXECUTIVE SUMMARY

This Remedial Investigation (RI) Report was prepared pursuant to Section 9.1(b) of the *Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study, Docket No. CERC-03-2009-0061DC*, effective April 9, 2009, between Foster Wheeler Energy Corporation (FWEC) and the United States Environmental Protection Agency (USEPA) (Settlement Agreement).

The FWEC/Church Road TCE Site (Site) is located in Mountain Top, Wright Township, Luzerne County, Pennsylvania. The Site consists of the following two areas, as shown in the figure below:

- The former FWEC Facility, located within the Crestwood Industrial Park Complex; and
- The Church Road TCE Site, including the Affected Area, as defined in the *Administrative Settlement Agreement and Order by Consent for Removal Response Action for the FWEC/Church Road TCE Site, dated August 29, 2005, Docket No. CERC-03-2005-0349DC* (2005 Order).

As indicated in Section 3.1 of the Settlement Agreement, this RI was conducted in order to further determine the nature and extent of contamination and the threats, if any, to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants or contaminants at or from the Site. In accordance with Section 2.1 of the USEPA-approved RI/FS Work Plan, the RI also had the objective of investigating whether certain other industrial facilities proximate to the Site ("Surrounding Industrial Properties" or "SIPs") contain independent source areas from which hazardous substances, pollutants or contaminants have been or are being released to the Site.

The field investigation activities performed to support the RI included: a Site reconnaissance; surface geophysical surveys; direct-push soil borings with direct sensing tools; groundwater screening evaluation; monitoring well installation; and sampling of environmental media including soil, groundwater, surface water, sediment, pore water, porous bedrock matrix, soil vapor, and indoor air. The data have been evaluated; a baseline human health risk assessment and a screening level ecological risk assessment have been completed; and the results are presented in this report.

Nature and Extent of Contamination

The results of the RI indicate that sources of chlorinated solvent-related contamination, specifically TCE and, to a lesser extent 1,1,1-trichloroethane (1,1,1-TCA), remain on the former FWEC Facility. Spatial data evaluation also indicate potential TCE contaminant sources in the vicinity of the CertainTeed, Bergen Machine and Fabri-Kal facilities. TCE from these potential sources would migrate into the Affected Area.

Groundwater with constituents above regulatory screening levels is present at the former FWEC Facility and in the Affected Area, as well as in the vicinity of the three SIPs mentioned above. Surface water and/or sediments in the former wastewater treatment pond (WWTP) on the former FWEC Facility property, as well as in select areas within Watering Run and its associated tributaries, also contain constituents above regulatory screening levels.

At the Site-wide scale, the RI results indicate that the TCE is present in a linear plume whose morphology is strongly influenced by regional and localized topography, bedrock structure, and localized variations in both horizontal and vertical hydraulic gradients. A TCE plume originates at the former FWEC Facility, flows in a generally southwesterly direction, exhibits a pronounced directional shift in the vicinity of the CertainTeed facility, and then flows westerly through the Affected Area to the western portion of the Site. The plume is generally narrow in width and exhibits a higher-concentration plume core throughout its length, indicating that migration is predominantly via advective transport with relatively limited lateral dispersion. The potential additional sources in the SIP area, as described above, would result in a comingled plume of undefined confluence.[1]

In certain areas of the Affected Area, the plume manifests itself at the surface in the forms of seeps and artesian flow from monitoring wells (i.e., EPA-1D during Round 3; RMW-04S-3 during Round 3; RMW-09S-1 during Rounds 1 and 3; RMW-09S-2 during Rounds 1 and 3; and three zones at RMW-09D during Round 3). The former is caused by the intersection of the uppermost aquifer with the steep topographic slope of the valley, and the latter is caused by vertically-upward flow from flow zones in bedrock at depth. The collected data also indicate that groundwater contamination identified south of the former FWEC Facility, on portions of the CertainTeed and Bergen Machine facilities, may be migrating locally in a northerly direction onto the former FWEC Facility property, apparently as a result of local groundwater gradients being reversed by the recovery wells associated with the groundwater extraction and treatment system (GETS) at the former FWEC Facility. Any such migration of contamination onto the former FWEC Facility is being treated by the GETS already in place.

The RI results verify that TCE-contaminated groundwater is present within unconsolidated till and bedrock, including weathered bedrock, highly-fractured bedrock and less-fractured, competent bedrock lithologies. The presence of the plume appears to be continuous within both the till and all bedrock lithologies, i.e., there do not appear to be distinct or isolated aquifers or hydrostratigraphic units separated by aquitards or aquitard-like conditions. However, the nature and quantitative characteristics of groundwater flow likely varies due to the naturally variable differences in the hydrogeologic properties of the till and the bedrock lithologies. As a result, contaminant migration and/or attenuation at different locations will vary accordingly.

Flow within the till is likely to correspond to unconsolidated deposit heterogeneity, with some degree of preferential flow as a function of the differences in hydraulic conductivity that naturally exist as a function of this heterogeneity. Flow within the weathered bedrock is variably influenced by the local degree of weathering, wherein flow would be dominated by historic fractures (secondary porosity) enhanced by weathering. Some degree of attenuation via diffusion into the weathered matrix (primary porosity) also is likely. Flow within the highly-fractured bedrock and less-fractured, competent bedrock is likely to be dominated by fracture flow, with probable higher transmissivity conditions existing within the more highly-fractured bedrock. A matrix diffusion investigation conducted on bedrock cores collected in the vicinity of the former vapor degreaser on the former FWEC Facility indicates that contaminants have diffused into the primary porosity (bedrock matrix) of the fractured, porous sedimentary bedrock.

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[1] Forensic chemical fingerprinting methods to evaluate distinctions with other potential sources, such as isotopic analyses, were not within the scope of the USEPA-approved RI/FS Work Plan.

Contaminant Fate and Transport

Groundwater data collected during the RI field investigation indicate that the operation of the on-site GETS, along with natural fate/transport mechanisms, have resulted in a decline in constituent concentration levels present at the former FWEC Facility, including the concentration of TCE. Natural fate/transport processes are also gradually reducing constituent concentrations within the Affected Area, where the data indicate a decline in TCE concentrations. Constituents in groundwater originating from the former FWEC Facility and potentially from the three SIPs noted above have migrated to the Affected Area and will persist until dilution, degradation, and removal by the GETS result in their eventual non-detection or until the impacted groundwater discharges to surficial seeps, springs or Watering Run.

In contrast to the declining trends at the former FWEC Facility and the Affected Area, concentrations of TCE detected in monitoring wells proximate to the three above-mentioned SIPs do not appear to have declined in magnitude between historic and more recent sampling events, which may also indicate the potential for additional, localized sources in the vicinity of the CertainTeed, Bergen Machine and Fabri-Kal facilities.

Baseline Human Health Risk Assessment

The baseline human health risk assessment (BHHRA) assessed the potential risks to human health for current and potential future exposure of individuals to constituents of concern found in environmental media at the Site and surrounding areas. The BHHRA evaluated four potential exposure areas (PEAs) associated with the Site and two other areas in order to more clearly delineate and assess the potential risks to human health from the presence of constituents of concern without regard to their source:

- The former FWEC Facility;
- The Affected Area;
- The SIPs; and
- Watering Run.

Potential health risks above target thresholds were identified for the former FWEC Facility with respect to potential future exposures to:

- TCE in groundwater that is hypothetically consumed by a potential future commercial worker;
- TCE in the soil that is directly contacted by a potential future commercial;
- TCE and several other volatile contaminants in indoor air inhaled by a potential future commercial worker conducting activities in an on-site building impacted by volatiles released from contaminated groundwater (assuming appropriate mitigation measures were not incorporated into the new structure);

- TCE in shallow groundwater that could be directly contacted by a potential future construction/utility worker;
- TCE in the soil by a potential future construction/utility worker (especially in the MIP1 Area);
- TCE, other volatiles and some inorganics in the soil and groundwater (if used for domestic supply) by hypothetical future child and adult residents; and
- Carcinogenic PAHs in the wastewater treatment retention pond (WWTP) sediment that could be directly contacted by a hypothetical future child resident.

The analysis also showed that if a current trespasser were to spend all of his/her time in the MIP1 Area and be exposed only to the surface soil there (in contrast to accessing and contacting the surface soil over the entire former FWEC Facility) exposure to TCE in the soil would lead to projected non-cancer risks above the target threshold.

Potential current health risks were identified for the Affected Area residents and commercial workers only if the shallow groundwater were to be used as a drinking water supply for the homes and businesses. These potential risks were associated with TCE, acrolein and iron in the groundwater. However, this potential exposure pathway has effectively been precluded by the connection of almost every residence and business to the municipal water system, as well as by deed restrictions prohibiting the use of groundwater by nearly all of the property owners within the Affected Area. At one residence where connection to the municipal water system was refused, the installation of a point-of-use groundwater treatment system mitigates this potential risk. However, a potential future groundwater ingestion risk will remain as long as contaminated groundwater is present in the Affected Area at concentrations above drinking water standards.

A comprehensive VI evaluation was performed at the residences and public buildings within the Affected Area that were identified in the Work Plan as having the greatest potential for VI based on an assessment of the distribution and measured concentrations of TCE in the groundwater beneath the Affected Area at that time. Sampling of some combination of the shallow groundwater, sub-slab vapor or soil gas from beyond the building foundation, and indoor and outdoor air was specified in the Work Plan as the methods for performing the VI investigation at these selected locations. The RI sampling results for VI were collectively evaluated at each sampled location using a three-step tiered process to determine whether the measured indoor air contaminant levels of any constituents could be due to VI from the underlying groundwater and whether they are present at levels that might pose an inhalation risk above conservative regulatory risk-based thresholds. The VI investigation approach that was employed was reviewed and approved by USEPA prior to implementation. This evaluation considered multiple lines of evidence and concluded that the levels of TCE measured in 2010 at the two residences associated with unique hydrogeologic and/or subsurface conditions (i.e., residential construction on the site of a natural spring and a leaking former well pump flooding the material beneath the foundation slab of another residence) could pose an unacceptable human health inhalation risk due to VI. However, active soil depressurization (ASD) systems were installed at both of these residences (i.e., Location 11 at 175 Church Road and Location 16 at 194 Church Road) in 2011 following the 2010 sampling event and analyses to mitigate the potential risks. Operation of these mitigation systems effectively eliminates this potential exposure pathway at these locations. The data and VI analysis for the Affected Area did not indicate a basis for similar VI risk to exist at other locations.

Based on approximately 10 years of groundwater data from groundwater monitoring wells and VI investigation sampling, the extent of the contaminant plume in the Affected Area is stable and the contaminant concentrations have declined over time due to the continuing operation of the Groundwater Extraction and Treatment System (GETS) at the former FWEC Facility and natural attenuation processes that are reducing the concentrations of many of the contaminants. In addition, the closure and cessation of pumping at the former private wells in the Affected Area has reduced the induced migration of groundwater toward the residences. This also has led to a reduction in the concentrations of volatile groundwater contaminants beneath the structures and a corresponding reduction in the potential VI at these locations. These ongoing activities and natural processes are expected to lead to further declines in the concentrations of the shallow volatile organic compound (VOC) groundwater contaminants in the Affected Area, and a further reduction in the potential for VI at these locations in the future. Based on the downward trend in contaminant concentrations and the installation and operation of the VI mitigation systems at the two residences associated with the unique subsurface conditions that increased the localized potential risk associated with VI, the current VI health risks for the Affected Area via the indoor air exposure pathway have been mitigated. However, a potential future VI risk will remain as long as the groundwater in the Affected Area is impacted by volatile organic compounds.

Two potential health risks were identified for the SIPs PEA relative to the local groundwater. The first was associated with the hypothetical consumptive use of the groundwater (i.e., used for drinking water and/or general commercial or residential use). However, these potential exposures are unlikely to occur because these businesses also are connected to the municipal water supply and the local groundwater is not used now, or is it likely to be used for those purposes in the future. The second highlighted potential risk was associated with the possible direct contact exposure to TCE in the shallow groundwater by a future construction/utility worker performing excavation on one of the properties impacted by the TCE plume at a location where the depth to impacted groundwater was relatively shallow.

The USEPA-approved RI/FS Work Plan did not require a targeted VI investigation for the SIPs. As a result, the data collected during the RI investigations, which included data relevant to the assessment of potential health risk relative to VI at the SIPs where TCE has been detected in the groundwater, was insufficient to perform a conclusive quantitative VI analysis for those SIPs. Based on the data collected during the RI investigation, structures associated with three particular SIPs (i.e., Bergen Machine, Certain Teed Corporation and, possibly, Fabri-Kal) may be located within 100 feet of the TCE groundwater plume migrating from the former FWEC Facility rather than being affected by localized sources.

No current health risks were identified for the Watering Run PEA. However, there is the potential for direct contact risk to a future construction worker. The potential risks associated with that potential future construction scenario were primarily associated with exposure to manganese in the sediments, not TCE.

Screening Level Ecological Risk Assessment
A Screening Level Ecological Risk Assessment (SLERA) was performed to conservatively assess the potential exposure and risks to terrestrial and aquatic ecological receptors from constituents found in environmental media to which these ecological receptors may be exposed. Environmental media evaluated as part of the SLERA included surface soils, surface water, surface sediments, and pore water. Results of the initial and refined screening evaluation determined that low level concentrations of TCE and other chemical constituents in the surface water and sediments associated with the seeps/springs did not pose a significant risk to aquatic life or amphibians, in these environments. In Watering Run, select metals were found to exceed benthic community benchmarks. These PEC exceedances were noted at SD06 and SD19 for manganese and iron at both stations within Watering Run. In addition, potential risks to benthic communities at SD19 were also associated with nickel and zinc. This was the only location where these PEC exceedances for all four metals was noted. The lack of corresponding background metals data for Watering Run prevented the assessment of variation in metals to better assess the significance of these exceedances relative to local background conditions, resulting in some uncertainty in this exposure and risk determination.

Sediments and surface water in the former WWTP contained chemicals of potential ecological concern (COPECs), including: polycyclic aromatic hydrocarbons (PAHs), pesticides, polychlorinated biphenyls (PCBs), and heavy metals that exceeded corresponding Ambient Water Quality Criteria (AWQC) and Sediment Quality Guidelines (SQG). A potential risk to pelagic organisms and benthic macro-invertebrates in the pond environment was identified, and the above suites of constituents were retained as COPECs for the WWTP. Many of the associated risks were associated with exceedances of SQGs at SD01 in the WWTP. The surface water and sediment in the WWTP warrant either further investigation to better quantify the potential risks predicted or implementation of a non-time critical remedial action to decrease the concentrations of these contaminants and thereby mitigate these potential risks.

Screening of surface soils data revealed that select PAHs present in the former Shot Blast Area and Expended Waste Area exceeded receptor specific ecological soil screening levels (Eco-SSLs) for terrestrial plants, soil invertebrates and wildlife receptors, such as mammals and birds. Potential risks of PAHs to avian receptors could not be initially assessed due to the absence of a corresponding Eco-SSL for this receptor group. Risks to these receptor groups were determined to be low in the former Open Area West of the Main Building.

Conclusions

The RI activities confirmed much of the prior understanding of the Site and surrounding area, including, but not limited to:

- The locations and extent of residual source areas on the former FWEC Facility;
- Geologic and hydrogeologic conditions, including the prevailing groundwater flow directions;
- The horizontal extent of impacted groundwater in the Affected Area (i.e., the boundaries of the plume are not expanding); and
- The absence of current VI concerns in the Affected Area, based on the direct evaluation of the measured conditions or the installation of VI mitigation systems at two residences with unique hydrogeologic and/or subsurface conditions that promoted localized VI migration.

Data collected during the RI have further demonstrated that:

- The concentrations of TCE in groundwater on the former FWEC Facility are declining due to the ongoing operation of the GETS and natural attenuation processes;
- The concentrations of TCE in groundwater in the Affected Area are declining as a result of natural attenuation processes and the operation of the GETS at the former FWEC Facility;
- Spatial data evaluation indicates potential TCE contaminant sources in the vicinity of the CertainTeed, Bergen Machine, and Fabri-Kal facilities. TCE from these potential sources would migrate into the Affected Area; and
- The concentrations of TCE in groundwater located proximate to the three above-mentioned SIPs do not appear to have declined in magnitude between the historic and more recent sampling events.

Based on the data analyses and risk assessment performed pursuant to the RI/FS Work Plan, there are no current human health risks, and there are no threats to ecological receptors that require or warrant immediate action. However, the potential for some future risks to Site users were identified if construction activities or redevelopment were to occur.

More specifically, if an extensive construction project were undertaken at the former FWEC Facility that results in handling of impacted soil or contact with groundwater in a trench and the construction workers failed to use common personal protective equipment or implement routine best practices, exposure to TCE in groundwater and TCE in MIP 1 soils could result in an unacceptable risk. Similarly, construction activity in the SIPs resulting in extensive contact with groundwater in a trench could result in an unacceptable risk due to TCE in groundwater in the absence of appropriate health and safety practices. Likewise, if construction activity were to involve extensive contact with the most contaminated Watering Run sediments, exposure to manganese in the sediments could result in an unacceptable risk in the absence of appropriate health and safety practices.

Unacceptable risks were identified for a number of hypothetical exposure scenarios, including those resulting from vapor intrusion from groundwater into a hypothetical future building at the Former FWEC Facility, assuming no vapor mitigation is incorporated into the construction of the new structure. Unacceptable risks were identified for hypothetical domestic use of groundwater at the Former FWEC Facility, the Affected Area, and the SIPs. Unacceptable risks also were identified for hypothetical use of groundwater in the workplace by a commercial worker (e.g., drinking water, sanitary supply). However, these hypothetical exposure pathways have effectively been precluded by the connection of virtually every residence and business to the municipal water system, as well as by deed restrictions prohibiting the use of groundwater by nearly all of the property owners in the Affected Area.

In addition, the potential for future risks associated with the groundwater in the Affected Area will remain as long as the groundwater is impacted by volatile organic compounds and residual contamination remains in the environmental media at the former FWEC Facility. The impacted media at the Site and associated migration pathways to other PEAs associated with potential future risks to human health have been sufficiently delineated to proceed to performance of the Feasibility Study for the Site, which will identify and evaluate potential remedial actions that might be appropriate to implement at the Site.

1.0 INTRODUCTION

Foster Wheeler Energy Corporation (FWEC) has prepared this Remedial Investigation Report (RIR) to describe the activities and findings of the remedial investigation (RI) conducted at the FWEC/Church Road TCE Site (Site). This RIR was prepared pursuant to Section 9.1(d)(4) of the *Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study, Docket No. CERC-03-2009-0061DC* (Settlement Agreement), effective April 9, 2009, between FWEC and the United States Environmental Protection Agency (USEPA). The information presented in this RIR was obtained and evaluated pursuant to the approved Data Gap Analysis Report (TtEC, 2009), the approved RI/FS Work Plan (TtEC, 2010), and current USEPA and Pennsylvania Department of Environmental Protection (PADEP) regulations and guidance documents.

1.1 Report Organization

This Remedial Investigation Report is organized as described below.

Section 1.0, Introduction, summarizes the purposes and objectives of the report and provides a description of the Site (including location, history, and previous remedial activities) and the surrounding properties.

Section 2.0, Study Area Investigation, describes the specific activities performed during the investigation of the environmental media at the Site. The sampling program objectives, procedures, and sample locations are discussed.

Section 3.0, Physical Characteristics of the Study Area, presents the physical and geological characteristics at the Site, including surface features, climate, demography and land use, geology, hydrogeology, and ecological assessment.

Section 4.0, Nature and Extent of Contamination, summarizes and, where appropriate, presents observations and draws conclusions or inferences from the analytical data obtained during the field program.

Section 5.0, Contaminant Fate and Transport, presents a general discussion on environmental fate and transport data and processes, followed by an analysis of site-specific factors and mechanisms that influence migration and contaminant fate and transport at the Site.

Section 6.0, Conceptual Site Model, synthesizes the major findings of the RI to provide a comprehensive understanding of Site conditions for the purpose of future decision making and planning.

Section 7.0, Human Health and Ecological Risk Assessments, summarizes the results of the risk assessments performed for the Site.

Section 8.0, Conclusions and Recommendations, summarizes the major findings of the RI and conclusions.

Section 9.0, References, includes a listing of references cited throughout the document.

Appendices are listed in the Table of Contents and provide and present the underlying data and information discussed in the narrative sections of the report.

1.2 Purpose of Report

As indicated in the Settlement Agreement, the RI was conducted to further determine the nature and extent of contamination and the threats, if any, to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants or contaminants at or from the Site. In addition, the RI was performed to develop the technical database needed for completion of a feasibility study (FS), which will identify and evaluate remedial alternatives to prevent, mitigate, or otherwise respond to or remedy, as necessary, any release or threatened release of hazardous substances, pollutants, or contaminants at or from the Site.

Specifically, the following tasks were performed as part of the RI:

- Performance of a comprehensive field investigation to obtain the data necessary to characterize the regional geologic and hydrogeologic framework for use in evaluating the potential migration pathways and exposure media of contaminants related to the potential release or any known or threatened release of contaminants at or from the Site.

- Collection of environmental samples (including surface and subsurface soil, groundwater, surface water, sediment, pore water, porous bedrock matrix, soil vapor and indoor air) to:

    - Identify potential sources of contamination at or in the vicinity of the Site;[2]
    - Define the nature and extent of contamination, if present, within these media at concentrations exceeding applicable or relevant and appropriate Federal and State requirements (ARARs) and/or “to be considered” guidelines (TBCs), where such concentrations are related to the potential release or any known or threatened release of contaminants at or from the Site; and,

[2] The scope of the EPA-approved RI/FS Work Plan did not include forensic chemical fingerprinting methods, such as isotopic analysis, to distinguish potential sources. If a potential secondary source of contamination was identified during assessment of the data collected during the RI, the results are discussed herein.

  - Use during the FS process to screen and evaluate potential remedial alternatives, as necessary.

- Characterization of the fate and migration of contamination, if present, and a determination of the potential impacts to off-site locations, where such concentrations are related to the potential release or any known or threatened release of contaminants at or from the Site.

- Obtainment of chemical, toxicological, and other data, related to the potential release or any known or threatened release of contaminants at or from the Site, to supplement the existing data set for use during the human-health risk assessment.

- Obtainment of biological, chemical, toxicological, and other data, related to the potential release or any known or threatened release of contaminants at or from the Site, for use during the screening level ecological risk assessment (SLERA).

- Determination of the current and potential future human health and ecological risks, related to the potential release or any known or threatened release of contaminants at or from the Site.

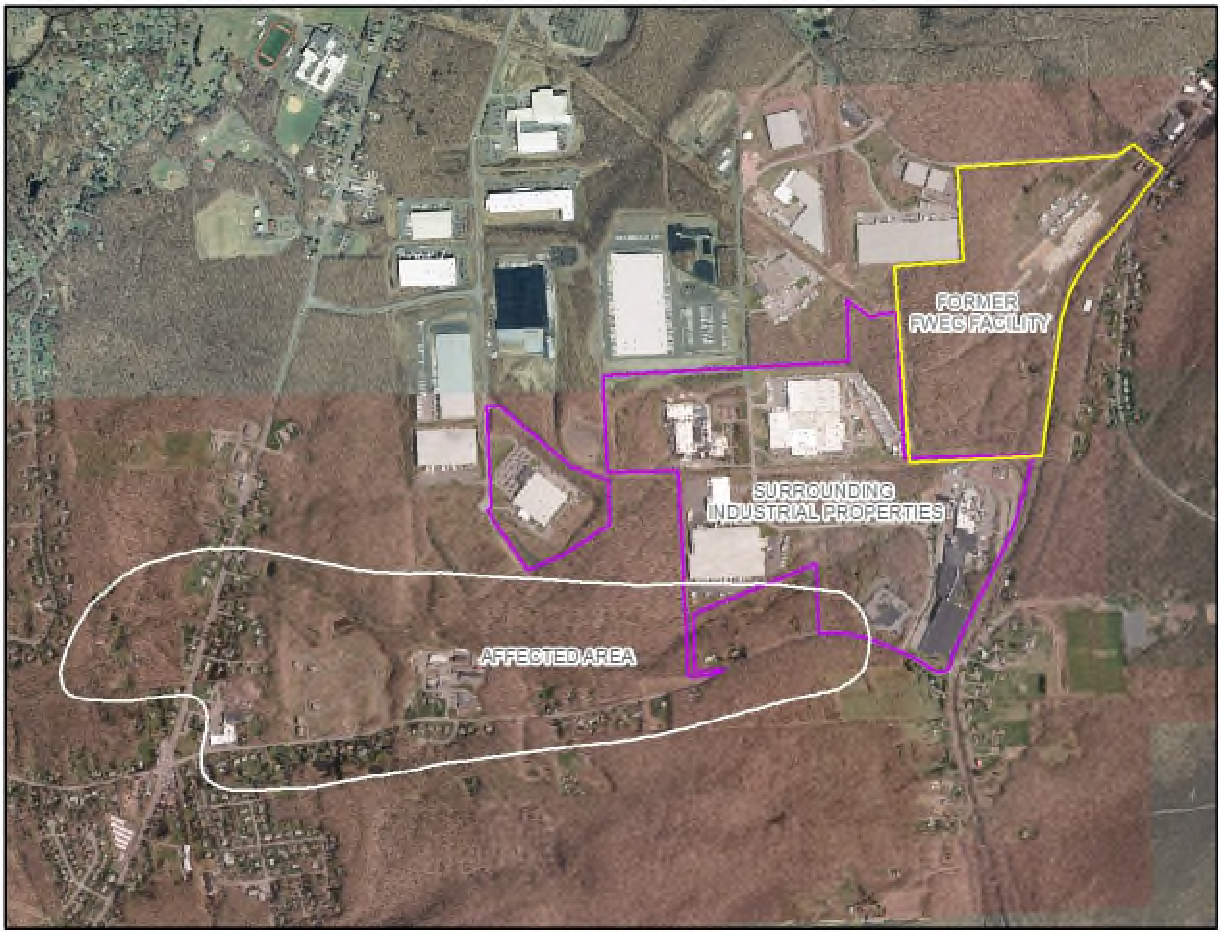
- Refinement of the Preliminary Conceptual Site Model (PCSM), originally presented in Section 6 of the Data Gap Analysis Report (TtEC, 2009), for utilization as a decision-making tool. This effort was supported by the evaluation of site data using recognized 2-dimensional data analysis and 3-dimensional visualization and analysis (3DVA) methods and software.

1.3 Site Location

The Site is located in Mountain Top, Wright Township, Luzerne County, Pennsylvania approximately 5 to 6 miles south of Wilkes-Barre, PA and is depicted on Figure 1-1. The Site includes the following two areas, as shown on Figure 1-2 and below:

- The former FWEC Facility, an approximately 105 acre property, located in the northeastern portion of the Site at 348 Crestwood Drive, within the Crestwood Industrial Park Complex;
- The Church Road TCE Site, including the Affected Area, as defined in the *Administrative Settlement Agreement and Order by Consent for Removal Response Action for the FWEC/Church Road TCE Site, dated August 29, 2005, Docket No. CERC-03-2005-0349DC* (2005 Order). The Affected Area extends from east to west along Church Road and Watering Run and is approximately 295 acres in size, and is generally located south and southwest of the former FWEC Facility.

In accordance with the USEPA-approved RI/FS Work Plan, an area consisting of eight separate Surrounding Industrial Properties (SIPs), located immediately south and west of the former FWEC Facility, as shown below, was also investigated during the RI for potential sources of contamination that could be migrating onto the Site.



1.4 Site History

1.4.1 Former FWEC Facility Property Ownership History

The following ownership history of the former FWEC Facility property was developed from, among other things, the summaries provided in the February 2005 Second Interim Title Search Report (Deeds and Leases) for the former FWEC Facility and the 2003 Special Industrial Area Baseline Environmental Report.

- The property was transferred to FWEC from the Wyoming Valley Industrial Building Fund on January 29, 1953. FWEC ceased operations at the property in 1984.
- On August 22, 1989, the property was transferred from FWEC to Morrison-Knudsen Company (MK). MK and its successors manufactured and remanufactured locomotives, small power control units (PCUs), and flat cars for rail transportation of tractor-trailers.

- MK transferred ownership to Morrison-Knudsen Rail Corporation (MK Rail) on April 18, 1994. MK Rail merged with and into MotivePower Industries on January 1, 1997. All operations at the facility by MotivePower Industries ceased at this time.
- MotivePower Industries merged with and into Westinghouse Air Brake Company (WABCO) on November 11, 1999, which subsequently merged with WABCO Merger Subsidiary, to create Westinghouse Air Brake Technologies (Wabtec) on December 23, 1999. Wabtec re-initiated operations at the facility, and the property was used for warehousing of products (primarily fiberglass insulation products) by third parties under a lease agreement with Wabtec.
- The former FWEC Facility property is currently owned by Wabtec. A deed for the property noting ownership by Wabtec is dated November 12, 2003.
- At the time of writing of this report, the last observed use of the property was tractor-trailer parking.

1.4.2 Former FWEC Facility Potential Sources

Previous documents investigating or studying conditions at the former FWEC Facility were utilized as background sources to describe the former buildings, structures, and operations at the facility. The documents utilized included:

- Real Estate Report (Sammon, 1984);
- Woodward Clyde Consultants (WCC) reports (WCC, 1986; 1987; 1989);
- Special Industrial Area Baseline Environmental Report (American Geosciences, Inc. [AGI], 2003); and
- USEPA Aerial Photographic and Fracture Trace Analyses of Foster Wheeler Energy Corporation Site (also known as the Environmental Photographic Interpretation Center [EPIC] Report; USEPA-R3, 2008).

With respect to reports prepared by or for others, FWEC's summarization or recitation of information furnished in these reports throughout this RIR should not be construed to mean that FWEC adopts or agrees with any or all of these reports' interpretations, hypotheses or conclusions. These reports speak for themselves and are cited here as part of the record in this matter.

Figure 1-3 indicates the former potential sources associated with the former FWEC Facility, MK, WABCO and Wabtec operations, illustrated on a 2011 aerial photograph of the property. Currently, a small building associated with the on-site groundwater extraction and treatment system (GETS), operated by FWEC, is located in the southeastern portion of the property. Other structures remaining at the Site include the former X-Ray Building and a portion of the former Main Building also used for X-Ray inspections.

1.4.2.1 Buildings and Features from Historic Reports and Documentation

Structures and facilities associated with the former FWEC Facility during FWEC's occupancy of the property consisted of the Main Building, the X-Ray Building, a wastewater treatment system (WWTS) area located north-northwest of the Main Building, a shot-blast sands storage area located west of the Main Building, a firebrick and asbestos waste storage building located south of the Main Building, an expended waste area south of the transformer station, and a former production well (currently MW-5). A vapor degreaser was located within the craneway strip at the southern end of the Main Building.

The Main Building was of typical high-bay construction with a steel structure and a concrete floor. The building housed a main production floor, a fabrication shop, office areas, a maintenance area and a warehouse area. The building was constructed circa 1953 and was used for main vessel assembly activities along with some shot blast operations and spray-painting in a shot blast unit and small paint booth. The 1984 Real Estate Report indicates the size of the Main Building was 195,618 square feet, with two smaller buildings totaling 8,436 square feet. Major additions to the Main Building were constructed in 1964, 1965, and 1971 (Sammon, 1984).

The X-Ray Building was a high-bay structure constructed between 1959 and 1966 with 4-foot thick concrete panel lower walls and floors. FWEC inspected welds for vessels in the building (AGI, 2003).

The former vapor degreaser, located on the south side of the Main Building, was used by FWEC to remove lubricants and cutting oils from machined parts. The vapor degreaser was a sealed 12-foot by 12-foot by 12-foot aboveground tank. A 12-inch layer of trichloroethylene (TCE) was heated, producing TCE vapors that cooled at the top of the covered tank and washed down over parts placed in the tank, removing oils and grease from the parts (WCC, 1986).

Other features of the Main Building included 22 structures identified as "waste oil pits" located within the Main Building floor and a hydrotesting sump at the northeastern corner of the building. The majority of these pits were machinery foundations and not intended for waste oil collection. Ten oil pits were used for storage or re-circulation of oil used in fabrication (WCC, 1989). The hydrotesting sump was utilized by FWEC to pressure-test fabricated vessels. The hydrotesting sump was a cylindrical underground metal tank, 10 feet in diameter and 20 feet deep (WCC, 1989).

The wastewater treatment system (WWTS), consisting of a clarifier and a retention/polishing pond, was located north-northwest of the Main Building. The clarifier was approximately 20 feet in diameter and approximately 7.5 feet deep. The polishing pond was generally rectangular in shape and measured about 140 feet long by 48 feet wide with a maximum depth of approximately 3 feet (WCC, 1989). A Pennsylvania Department of Environmental Resources (PADER) permit for construction and operation of a new wastewater treatment plant was issued, but FWEC subsequently abandoned its plans for this facility and cancelled the permit. The former FWEC Facility reportedly was connected to the public sewer in November 1979 (GFEE, 1985) or possibly in 1980, as the 1984 Real Estate Report indicates sewer connections to the property were completed in 1980 (Sammon, 1984).

Following transfer of the property to MK in 1989, MK constructed four new buildings in 1991 to support locomotive manufacturing operations. These buildings are observed on the 1992 aerial photograph and are identified as the Wash Building, Shot Blast Building, Prime Paint Building, and Finish Paint Building. These buildings were constructed with pre-fabricated steel erected on slab-on-grade foundations (AGI, 2003).

Locomotives were initially cleaned in the Wash Building, located southeast of the main building. Fuels and oils were drained from the locomotives and collected, with diesel fuel stored in a 30,000 gallon aboveground storage tank (AST) adjacent to the Wash Building. The locomotives were high-pressure washed over a 10-foot wide by 5-foot deep poured concrete pit, and the collected wash water generated during this process was treated at the WWTS, located within this building, prior to discharge to the sewer system or re-use on-site. Shot blasting of painted locomotive bodies occurred in the Shot Blast Building, located southwest of the Main Building. A large shot blasting enclosure and a dust collector for managing the exhaust air was located inside the building (AGI, 2003).

Painting operations were conducted at the Prime Paint and Finish Paint Buildings. Each building contained a large painting enclosure capable of surrounding a locomotive. Locomotives, and later PCUs, were painted at each of these buildings (AGI, 2003).

The 2003 AGI report indicated several smaller buildings were present to the east of the Finish Paint Building and southwest of the developed area of the Main Building. The locations of the buildings were not presented on the figures included in the AGI report; however, the buildings were referred to as the Solvent Building and Paint Storage Building. These buildings formerly stored solvents and paints, respectively, and were equipped with metal pan secondary containment and explosion-proof fixtures. The AGI report indicates the buildings were constructed circa 1989 (AGI, 2003).

According to the AGI report, a small pre-fabricated building was located in a wooded area of the property near the former expended waste area and southeast of the developed area of the Main Building. The building was known as the Sand Storage Area Building, and formerly, the "detnotesting" building for FWEC (AGI, 2003). In the August 22, 1989 Deed for transfer of the property from FWEC to MK, this area was identified as a "Disposal Area" in the Notes to Exhibit "A."

1.4.2.2 Buildings and Features from Aerial Photography Review

A historic aerial photograph analysis of the former FWEC Facility and surrounding area was performed by the USEPA, and the findings were presented in the May 2008 EPIC Report (USEPA-R3, 2008). Ten aerial photographs were obtained and evaluated to perform the historic aerial photograph, with nine of the photographs reproduced in the EPIC Report. The nine photographs included in the report were from 1939, 1950, 1959, 1966, 1969, 1981, 1988, 1992, and 2005. The purpose of the analysis was to document landscape characteristics and changes, evaluate patterns of waste disposal, and identify other conditions exhibiting potential environmental significance.

Unless otherwise referenced, the following information is based on a review of the EPIC Report as regards to the former FWEC Facility property. In the following summaries, unless indicated otherwise, all references to aerial photographs are to the aerial photographs and their interpretive legends provided in the EPIC Report.

- The 1939 aerial photograph indicated the area that became the former FWEC Facility property and surrounding area was primarily forested and undeveloped, with a rail line running parallel to its eastern property boundary. In addition, an area of residential and/or agricultural land use is depicted in the southeastern portion of the property that would later become the former FWEC Facility property.

- The 1950 aerial photograph depicts the same area of residential and/or agricultural land use in the southeastern portion of the property as depicted in the 1939 aerial photograph. It also depicts a possible rectangular feature in this area. A map showing property to be conveyed to Foster Wheeler dated January 5, 1953 shows three parcels of land and a road labeled "old road" in this area. The map was included with the Deed conveying the parcels from Wyoming Valley Industrial Building Fund, Inc. to Foster Wheeler. No other development is depicted on the land that would later become the former FWEC Facility property.

- Development of the former FWEC Facility was first indicated in the report text related to the 1959 aerial photograph. The 1959 aerial photograph depicted the Main Building located adjacent to the rail line at the former FWEC Facility. A possible transformer yard was depicted at the southwest end of the building footprint, and two horizontal storage tanks were depicted near the southernmost railroad spur. The EPIC Report text indicates that runoff from near these storage tanks and possible transformer yard is directed south.

The 1959 aerial photograph depicted two features that, according to the interpretive legend, are both defined as an "impoundment" and "standing liquid." The first is depicted at the location of the former WWTS. With regard to the second, the EPIC report's text states that, "south of this facility is a square-shaped impoundment containing standing liquid." This second "impoundment" is noted on the aerial photograph in the same location as the area of residential and/or agricultural land use depicted in the 1939 and 1950 aerial photographs and appears to be the same feature depicted in the 1950 aerial photograph. Based on reconnaissance conducted in this area of the former FWEC Facility property, evidence of a former foundation and bridge are apparent, indicating that the rectangular feature was likely a structure associated with the residential and/or agricultural use of the parcel(s) by prior owner(s).

- The report's text states a large open storage area containing numerous pipes was near the possible transformer yard in 1966. Two additional horizontal storage tanks and the impoundment and standing liquid discussed above were also depicted in the 1966 aerial photograph.

- The 1969 aerial photograph depicted possible pipes or storage tanks located near the southeastern limits of the Main Building. Two possible vertical storage tanks and an unidentified object are located near the impoundment containing standing liquid, at the location of the former WWTS. The EPIC Report states these features remain present in the 1981 aerial photograph.

- The EPIC Report states the facility appears to be inactive in 1988. The Report's text states that a collection of debris and potential solid waste appears to be present near a liquid-filled impoundment.

- The 1992 aerial photograph noted additional buildings not present in previous photographs located south and southwest of the Main Building, and southwest of the developed area of the Main Building. These structures appear to be the Wash Building, Shot Blast Building, Prime Paint Building, Finish Paint Building, Solvent Building, and/or Paint Storage Building as identified in the AGI report (AGI, 2003).

- In 2005, the EPIC Report's text states that the Main Building has been removed and only three of the four new buildings seen in 1992 are visible. Debris is depicted on the aerial photograph within the former footprint area of the building. The liquid-filled impoundment and other features located near the former WWTS are depicted on the 2005 aerial photograph west of the former location of the Main Building.

1.4.2.3 Bedrock Fracture Trace Analysis

A bedrock fracture trace analysis was performed by USEPA in 2008 to identify zones of fracturing in the bedrock that could act as preferential pathways for subsurface contaminant flow. Four fracture traces were identified, only one of which was located near the Site. Figure 3-4 depicts the location of the identified fracture trace near the Site in relation to local bedrock geology. (USEPA-R3, 2008)

1.4.3 Church Road TCE Site including Affected Area

The following information regarding the Church Road TCE Site, including the Affected Area, is based on a review of the EPIC Report (USEPA-R3, 2008).

- Several residences, agricultural land, and dirt roads were noted along Church Road as early as 1939. These features were also identified in the EPIC Report's textual analysis of the 1950 aerial photograph.

- In 1959, additional residences were depicted along Church Road and South Mountain Boulevard. A junkyard was noted near the intersection of Church Road and the railroad tracks.[3]

- Additional residential development was noted in 1966 along Church Road and South Mountain Boulevard, and the EPIC Report's text states the junkyard remains active. Analysis of the aerial photograph indicated the presence of solid waste, debris, and probable stained ground at the junkyard.

- In 1969, additional residential development was noted along Church Road and South Mountain Boulevard. The report text states the junkyard remains active with similar conditions to those noted in 1966.

- Residential development was depicted southeast of the intersection of Church Road and South Mountain Boulevard in 1981. The automobiles previously depicted at the junkyard had been removed. Ground scars and possible stained ground were noted at the junkyard, and a possible strip mine was indicated east of Church Road.

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[3] The junkyard was not specifically investigated during the RI due to denial of access for a planned groundwater screening location.

- Ground scars and debris were depicted at the junkyard location in the 1988 aerial photographs, but no automobiles were indicated at this location in 1988. The possible strip mine located east of Church Road was depicted in the 1988 photograph.

- In 1992, no changes were depicted at the junkyard location. The EPIC Report states fill has been added to the location of the potential strip mine.

- The report text states a portion of the potential strip mine appears re-vegetated by 2005, and adjacent areas appear disturbed, indicating an increased level of activity in this area.

1.4.4 <u>Summary of Previous Environmental Investigations and Actions</u>

The following paragraphs summarize environmental investigations and environmental remediation activities that have been undertaken, in addition to the RI activities discussed in this document, to address environmental issues associated with the Site. Several of these investigations included the installation of monitoring wells on the former FWEC Facility. Throughout this report, these wells are referred to as "existing" wells.

- *1980:* An electrical transformer in the main bay of the Main Building leaked Pyranol, a coolant containing polychlorinated biphenyls (PCBs), onto the concrete floor of the facility on February 11, 1980. The estimated area affected by the spill was 30 feet by 70 feet and included an area along the interior railroad tracks. The spill was reported, cleaned, and waste was disposed in accordance with regulations applicable at the time of the spill (USEPA, 1988a; WCC, 1989; USEPA-R3, 1989).

- *1985 and 1986:* Gannett Fleming Environmental Engineers (GFEE) conducted an environmental assessment of the property for Crest Foam Corporation prior to their potential acquisition of the property (GFEE, 1986). Elevated concentrations of PCBs were detected in wipe and chip samples collected from a concrete slab at a PCBs spill area from 1980. Elevated concentrations of TCE were detected in soil samples collected from surface and subsurface soil at the former vapor degreaser. The GFEE assessment suggested further investigation be undertaken at the former vapor degreaser, the PCBs spill area, and the hydrotesting sump.

- *1986:* In May, PADER sampled eight residential wells near the Site. Reportedly, no VOCs were detected in the water samples (AIG, 2003).

- *1986 to 1989:* WCC conducted a series of investigations from 1986 to 1989 on behalf of FWEC. The results of these investigations were presented in the following reports: Field Investigation Report – Phase I (June 1986); Field Investigation Report – Phase II (February 1987); Site Investigation Program (June 1988); and Site Remediation Program (December

1989). Data obtained during these investigations resulted in a determination that several areas of concern identified at the former FWEC Facility did not require further investigation or action and were satisfactorily addressed. Exceptions included the former vapor degreaser and the WWTS located at the northwestern portion of the former FWEC Facility.

- *1986:* A preliminary assessment (PA) was performed by NUS Corporation, under contract with the USEPA, in August 1986 (AIG, 2003).

- *1988:* In February 1988, FWEC, USEPA, and PADER entered into a *Consent Agreement and Order, Docket Number III-88-08-DC* (1988 Order) (USEPA, 1988a). The 1988 Order required FWEC to submit a Site Investigation Program containing a summary of all previous and ongoing investigations conducted by FWEC, its representatives, and other interested parties.

- *1989:* Investigation activities were performed in August and September 1989 by CH2M Hill on behalf of MK (CH2M Hill, 1990). The evaluation included a review of aerials photographs, a record search, a soil investigation in select areas of the former FWEC Facility, and installation and sampling of 13 groundwater monitoring wells.

- *1989:* CH2M Hill, on behalf of MK, removed former underground storage tanks (UST) in September 1989 following transfer of the property from FWEC to MK. The following were excavated and disposed: two fuel oil USTs (1000- and 10,000-gallon) north and west of the X-Ray Building; three 30,000-gallon fuel oil USTs east-southeast of the Finish Paint Building; and one 500-gallon gasoline UST west of the southeastern corner of the Main Building.

- *1991 through present:* WCC, on behalf of FWEC, implemented design and construction of an Interim Remedial Measure (IRM), consisting of a GETS, to remove contaminants, specifically TCE, from groundwater, and to control and stabilize the contamination downgradient of source areas and near the site boundary. The Interim Remedial Design for the facility was submitted to USEPA in October 1991, and approved by USEPA in a letter dated January 9, 1992. Copies of the design document and approval letter are provided in Appendix A. The interim groundwater treatment system commenced operations in October 1993.

  Treated effluent from the GETS is discharged to the headwaters for Watering Run, a drainage feature located at the southern portion of the former FWEC Facility property. Four extraction wells, two near the former vapor degreaser source area and two near the former FWEC property's southern boundary, remove and treat groundwater affected by TCE from the hydrostratigraphic units underlying the Site. Quarterly (1995 through

September 1997), and then annual (1998 through present) sampling was conducted to monitor the effectiveness of the GETS. FWEC submits annual progress reports presenting the activities and sampling associated with the GETS to USEPA and PADEP. The GETS remains in operation as of the date of this report. Evaluation of the interim groundwater treatment system performance and potential enhancements to the system will be performed as part of the FS for the Site.

- *1997:* Quad Three Group (Q3G), on behalf of MotivePower Industries, performed a Limited Phase II at each of the former UST excavations.

- *2000:* In November 2000, AGI, on behalf of Wabtec, installed two additional monitoring wells near the southern property boundary.

- *2003:* AGI, on behalf of Wabtec, conducted a baseline remedial investigation and prepared a Baseline Environmental Report for the former FWEC Facility property. Wabtec was seeking to obtain relief from environmental liability for the property through the Special Industrial Area (SIA) provision under the Pennsylvania Land Recycling and Environmental Remediation Standards Act (Act 2).

  The purpose of AGI's investigation and report was to present the information necessary to satisfy the reporting requirements of the SIA. AGI's report states that, given the extensive amount of investigation work conducted at the Site, the nature and extent of contamination were identified in accordance with the applicable requirements. AGI's report presents a summary of the previous investigations and a comparison of results to the PADEP Act 2 criteria (current as of 2003), where applicable. AGI's report can be generally summarized as having concluded that (i) contaminants in or affecting groundwater from the former vapor degreaser are being addressed by the GETS, and (ii) the other potential/known sources of contamination at the former FWEC Facility have been remediated or otherwise satisfactorily addressed, do not contain contaminants above current applicable criteria, and/or are not associated with a potential exposure pathway (AGI, 2003).

- *2004:* In September 2004, groundwater samples were collected from 16 wells located at residential properties along Church Road. Analytical results indicated detected concentrations of TCE in 15 of the 16 samples collected, ranging up to 160 micrograms per liter (μg/l). Fourteen of the samples contained concentrations above the USEPA Maximum Contaminant Level (MCL) of 5 μg/l. Bottled water was provided to affected residences, and additional samples from residential wells were collected. Carbon filtration systems were installed at residences where TCE was detected in samples collected from residential wells and were operated until the residences were permanently connected to the public water supply.

- *2004 to 2013:* Beginning in late 2004, sampling was conducted by FWEC on a monthly, then quarterly basis at certain affected residential wells to monitor the nature and extent of TCE in groundwater in the Affected Area, and at seven water wells located on six residential properties that serve as guardian or sentinel wells, defining the extent of the Affected Area. After the affected residences were connected to public water, sampling was conducted quarterly at the six guardian well properties and selected seeps within the Affected Area. The final quarterly sampling event was completed in February 2013.

- *2007:* As of July 21, 2007 and in accordance with the 2005 Order and approved Response Action Plan, FWEC had completed the final connections to public water at all 36 locations for which FWEC had received signed Water Line Agreements. At the remaining residence at which TCE was detected in a sample taken from a residential well, USEPA determined that FWEC is not required to provide a connection to public water because the owners of the residence have refused to accept a connection to public water or to sign a Water Line Agreement. As documented in Monthly Progress Report No. 33, three carbon filter tanks were purchased for the residence.

- *2008:* By May 23, 2008, all identified wells in the scope of work for the well abandonment activities submitted to USEPA on July 6, 2006 had been abandoned. In addition, as noted in Monthly Progress Reports submitted to USEPA, several wells that were not identified in that scope of work also were abandoned. As of the date of this report, 41 wells have been abandoned.

- *2009:* Representatives of USEPA and FWEC executed a First Amendment to the 2005 Order, effective April 2, 2009. The First Amendment includes connecting up to four additional homes located adjacent to the Affected Area to public water and covering a groundwater seep with gravel. In May 2009, FWEC prepared a Response Action Plan (RAP) Addendum related to the above-described First Amendment, which was approved by USEPA on June 24, 2009. In December 2009, the IRM for the seep was completed by removing vegetation and placing a filter fabric and gravel over the seep to eliminate the potential for human and animal contact with groundwater contaminated with TCE.

- *2009:* USEPA and FWEC executed the Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study (RI/FS) on April 3, 2009 and FWEC initiated RI/FS activities. In September 2009, the Data Gap Analysis Report (DGAR) was issued (TtEC, 2009).

- *2010 to Present*: In March 2010, the RI/FS Work Plan was issued and RI activities discussed in this document commenced.

- *2011*: An enhancement to the seep IRM was installed in September-October 2011. The enhancement consisted of installation of an electric powered aeration system to aerate the water in the man-made structure located adjacent to the seep to reduce the concentrations of TCE in the surface water seep adjacent to the structure.

- *2012*: In September 2012, the Response Action Report was issued to close out activities required in the 2005 Order. Activities completed included quarterly groundwater sampling, connecting residents to the municipal water supply, abandoning private water wells, and mitigating the groundwater seep at 192 Church Road. USEPA notified FWEC in a September 28, 2012 letter that FWEC had performed and satisfactorily completed the actions required under the Order.

1.4.5 Potential/Known Sources of Contamination at the Former FWEC Facility

As discussed in the DGAR (TtEC, 2009), 14 potential or known sources of contamination were identified at the former FWEC Facility from prior investigation activities. These potential/known sources were discussed in detail in Section 3.1 of the DGAR (TtEC, 2009). A copy of Table 2 from the DGAR, which summarizes these potential/known sources, is provided in Appendix B. Figure 1-3 depicts the locations of these potential source areas.

Based on an evaluation of the historic documents, data obtained during previous remedial investigations at nine (9) of the 14 potential/known sources or areas of contamination at the former FWEC Facility indicated that each of those nine areas (i) has been remediated or otherwise satisfactorily addressed, (ii) does not contain contaminants above current applicable criteria, and/or (iii) is not associated with a potential exposure pathway. No further remedial investigation of these areas was recommended in the DGAR (TtEC, 2009), and approved by USEPA. The five (5) remaining potential sources of contamination at the former FWEC Facility which were further evaluated as part of this RI are shown on Figure 1-3 and below and include:

1a. – Former Vapor Degreaser Area

1h. – Former Wastewater Treatment System

1l. – Former Shot Blast Area

1m. – Former Expended Waste Area

1n. – Area near former Finish Paint Building and former buildings located east of Finish Paint Building (e.g., Solvent Building and Paint Storage Building)

1.5 Surrounding Industrial Properties

The former FWEC Facility is located within Crestwood Industrial Park. Crestwood Industrial Park is approximately 1,050 acres in size and is utilized by industries and manufacturers for mixed industrial use. Eight SIPs are located within approximately 0.25-mile distance of Watering Run. Some, but not all, of these commercial properties are located between the former FWEC Facility and the Affected Area. These facilities represent the most proximal industrial locations, besides the former FWEC Facility, that could potentially be contributing contaminants via single or multiple migration pathways to Watering Run and groundwater.

The eight SIPs include the following sites, which are identified based on the last known occupant of the facility and street address. The industrial properties are presented on Figure 1-4 using the following number/letter key:

2a. Fabri-Kal, 955 Oak Hill Road

2b. i2M, 755 Oak Hill Road

2c. Quaker Oats/Gatorade, 750 Oak Hill Road

2d. Bergen Machine, 1120 Oak Hill Road

2e. CertainTeed Corporation, 1220 Oak Hill Road

2f. Former HPG Warehouse, 1335 Oak Hill Road (Building referred to as Cornell #1 in February 13, 2004 Lease Agreement)

2g. Cornell Iron Works, 100 Elmwood Road

2h. MarChem Northeast, 855 Oak Hill Road

Table 1-1 presents an overview of each property, including, but not limited to, its known current and former occupants, a brief description of the operations performed at the property and specific features of environmental significance which potentially could have resulted in or influenced the contributions from those properties of the contaminants affecting environmental media at the Site. The presence of historical site features such as impoundments and related liquid treatment systems, storage tanks, solid waste, and other debris at the SIPs were generally identified from a review of USEPA's EPIC Report (USEPA-R3, 2008); regulatory file review documents obtained from PADEP's files located in the Wilkes-Barre, PA office; and responses from each property's occupant to USEPA's 2005 104(e) questionnaire. Further details are provided in the DGAR (TtEC, 2009).

As discussed in Sections 5 and 6, investigation results identified additional potential TCE contaminant sources in the vicinity of the CertainTeed and Bergen Machine facilities located south of the former FWEC Facility, and in the vicinity of the Fabri-Kal facility located west of the former FWEC Facility. The collected data also indicate that groundwater contamination identified south of the former FWEC Facility, on portions of the CertainTeed and Bergen Machine facilities, may be migrating locally in a northerly direction onto the former FWEC Facility property, apparently as a result of local groundwater gradients being reversed by the recovery wells associated with the GETS at the former FWEC Facility. Any such migration of contamination onto the former FWEC Facility is being treated by the GETS already in place.

2.0 STUDY AREA INVESTIGATION

This section discusses the field investigation and data evaluation activities conducted during the RI. These tasks were performed to obtain and evaluate the data necessary to fulfill the data needs and project quality objectives (PQOs) discussed in Section 2.1 and 2.2 of the RI/FS Work Plan, including the overall objective of the RI project, which was to further determine the nature and extent of contamination and the threats, if any, to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants or contaminants at or from the Site. The RI/FS Work Plan also called for investigation of the SIPs to determine if one or more SIPs are sources of contaminant releases to the Site. The field activities discussed in this section were performed in accordance with the USEPA-approved RI/FS Work Plan. Due to conditions encountered in the field, minor modifications to the approved RI/FS Work Plan were documented on Field Change Requests (FCRs), which are provided in Appendix C, and were approved by USEPA prior to implementation.

The RI field investigation consisted of the following activities:

- Mobilization;
- Site reconnaissance;
- Vapor intrusion investigation;
- Surface geophysical surveys;
- Direct-push soil borings with direct sensing tools;
- Groundwater screening evaluation;
- Borehole and monitoring well installation;
- Bedrock matrix diffusion evaluation;
- Surface water, sediment and pore water sampling;
- Hydraulic testing;
- Elevation measurements;
- Groundwater sampling;
- Land survey;
- Quality control;
- Investigation derived waste (IDW) characterization and disposal; and
- Demobilization.

Data evaluation activities included:

- Field-based quality reviews and data quality review and validation according to USEPA guidance;
- Desk-top analysis of all data sets including data compilation, sorting, summarizing, and evaluation;
- 2-dimensional geospatial analysis using geographic information systems (GIS) technologies (ESRI ArcMap) and C Tech Development Corporation's Mining Visualization System (MVS); and,
- 3-dimensional visualization and analysis (3DVA) using specialty methods and MVS.

2.1 Mobilization

The purpose of mobilization was to familiarize the project team members, i.e., Tetra Tech, Inc. (Tt) personnel and key subcontractors, with the Site and field investigation activities, and to assemble equipment and support facilities. The mobilization effort established the base of field operations and consisted of logistical planning, precise identification of sampling locations, equipment mobilization to the Site, and field personnel orientation.

Office-based mobilization activities began on March 31, 2010, and continued, as required, prior to deployment to the Site for individual RI field tasks. The following activities were conducted:

- Prepare subcontractor procurement specification packages and award subcontracts;
- Identify and obtain the required field equipment and materials; and
- Provide support for access to properties.

On-site mobilization, which began on May 17, 2010 and continued as applicable throughout the RI, consisted of the following activities:

- Organization and storage of equipment and supplies;
- Establishment of a decontamination area, including temporary decontamination pad (constructed by Parratt-Wolff, Inc. on November 15, 2010);
- Establishment of an IDW staging area;
- Staking/marking of intended sampling locations;
- Identification of work zones;
- Performance of a site-specific orientation briefing for project team members;
- Set up of monitoring equipment calibration area; and
- Posting of required health and safety documentation.

Supplies and consumables necessary for the field investigation were obtained throughout the RI from appropriate commercial markets. The Tt Site Manager inspected materials prior to use, ensuring they met any specific requirements outlined in the RI/FS Work Plan. The Tt Site Manager also ensured that necessary equipment was properly obtained, secured, maintained, operated, and decontaminated throughout the RI field investigation. Supplies, consumables or equipment not meeting applicable requirements were returned to the supplier, and replacement material/equipment was acquired. The Tt Site Manager regulated the inventory of consumable supplies on-site, controlling access to them and ensuring that they were stored properly and used only for their intended purpose.

Prior to the commencement of each field activity, potential sampling locations related to that activity were staked and marked in consideration of access agreements, the presence of utilities, clearance restrictions, and vehicular traffic. USEPA Region 3 and other stakeholders were consulted for concurrence and approval of the monitoring well locations and construction, and the surface water/sediment/pore water sample locations. The Tt Site Manager contacted the One-Call Notification center, and oversaw other mark-out activities performed by subcontractors using electronic line tracing, ground penetrating radar (GPR) surveys, magnetometer surveys, and conductivity surveys as needed throughout the field investigation activities.

2.2 Site Reconnaissance

The Site Reconnaissance Task included repairing fences along the boundary of the former FWEC Facility property, conducting an ecological resources reconnaissance, and conducting reconnaissance to identify, confirm, and/or clarify the status and use of both the properties at the Site and of certain surrounding properties. Details of each of these activities are discussed in the following paragraphs.

2.2.1 Fence Repair

Portions of the fences restricting entry into the former FWEC Facility property appeared in need of repair at the time of RI/FS Work Plan development. On November 15, 2010, Wabtec, the property owner, was contacted by Alexander Valli of Tt in regard to fence repairs. Beach Fence Company performed repairs of the fences on November 22, 2010, which consisted of replacing 166 by 6 feet of galvanized chain link fence with end posts, top rails and three strand barb wire, installing a 31-foot roll gate with a 4-inch end post, and removing and hauling old fence.

2.2.2 Ecological Resources Reconnaissance

A sampling station and habitat reconnaissance was performed in tandem with a representative of the USEPA Region III Biological Technical Assistance Group (BTAG) on April 27, 2011. To assist in the characterization of the environmental setting for the former FWEC Facility and Affected Area, a qualitative habitat survey was conducted on October 6, 2011 to describe the vegetation cover types, aquatic habitats and record wildlife observations. Observations made during both events were used to define the environmental setting present, assist in development of a preliminary ecological conceptual site model and identify potential ecological receptors for evaluation in the SLERA (Appendix L).

In addition, the potential for a historic and/or current sheet-flow pathway for the Bow Creek watershed was evaluated. The outflow from the historic wastewater treatment pond (WWTP) was found to be channeled to the north to an intermittent roadside ditch. This road side ditch converged with a drainage conduit which directed flow beneath Crestwood Road into an unnamed tributary to Bow Creek.

2.2.3 Reconnaissance of Potential Sources

A Site reconnaissance was conducted to identify, confirm, and/or clarify the status and use of the properties within the FWEC/Church Road TCE Site, including the Affected Area, and also such matters for the SIPs. Access to potential sample locations was evaluated and contingency sample locations were identified, as necessary.

A Site reconnaissance also was conducted at the former Shot Blast Area and Expended Waste Area at the former FWEC Facility on October 28, 2010. The site reconnaissance indicated the former Shot Blast Sands Storage Area contained areas of sparse vegetation. The surface of the property in this area appeared to contain very densely packed sandy material. Topography was relatively flat, with a slight downward slope to the north.

Reconnaissance of the former Expended Waste Area showed a relatively flat, mostly vegetated area. Sections of former concrete slabs and footings were visible. The area was surrounded by vegetation including trees.

Based on the site reconnaissance and lack of historical laboratory results for the former Shot Blast Sands Storage Area and the Expended Waste Area, it was recommended that additional sampling activities be performed in these areas to determine the absence or presence of potential environmental concerns. Five (5) surface soil samples were collected from the Shot Blast Sands Area and analyzed for TCL SVOCs and TAL metals, and four (4) surface soil samples were collected from the Expended Waste Area and analyzed for TCL SVOCs and TAL metals. Additional details are provided in FCR-01 (Appendix C).

To document native soil concentrations for metals (i.e., background values) for comparison, soil samples were collected from ten areas in the vicinity of the former FWEC Facility that had not been impacted by previous industrial activity. Samples were generally obtained from 0 to 1 foot bgs and 1 to 2 feet bgs in April 2016 and analyzed for TAL metals. Details of the sampling are provided in FCR 14, along with a sample location map.

Six locations in the Shot Blast Sands and Expended Waste Areas (03 through 06) were re-sampled to evaluate the potential for the presence of hexavalent chromium (FCR 14). These additional soil samples were collected in April 2016 and analyzed for chromium, hexavalent chromium [Cr(VI)], total solids, oxidation-reduction potential (ORP), and pH.

2.3 Vapor Intrusion Investigation in the Affected Area

A focused vapor intrusion (VI) investigation that utilized a "multiple lines of evidence" approach was conducted for the Affected Area. This evaluation utilized groundwater concentration data, known physical properties of contaminants of concern, information regarding the physical setting, field-screening data, visual and olfactory observations, and analytical data that were obtained during the RI VI investigation, including shallow groundwater data, sub-slab vapor and/or soil gas data, and indoor air sampling data. The VI investigation was conducted using appropriate regulatory and scientific guidance including, among other guidance, USEPA Region 3's Vapor Intrusion Framework (USEPA-R3, 2009) to characterize and evaluate the potential for VI into the overlying structures within the Affected Area. The methodology and approach to the VI analysis was reviewed and approved by USEPA prior to implementation. Details regarding the VI investigation are presented in the following sections, and the results of the vapor intrusion investigation are presented in Section 4.4.

2.3.1 Technical Approach

In support of the RI/FS Work Plan development, existing data, such as the maximum historic TCE concentrations in groundwater (pre-treatment) in existing residential wells collected by representatives of FWEC prior to the abandonment of each well, groundwater elevations, and depth of well casing data were evaluated to identify potential trends in the data. To evaluate the maximum historical groundwater TCE concentration in the Affected Area by location, a quantile plot was prepared and presented as Figure 3-11 in the RI/FS Work Plan. A copy of this figure is provided in Appendix B. In preparing the plot, USEPA's Generic Target TCE Groundwater Concentration of 5 ug/L was used as a lower limit for the evaluation of the groundwater data (USEPA, 2002; USEPA-R3, 2009). The quantile plot graphically represented each data point so that the distribution of the data could be observed. The distribution indicated that the sampled locations in the Affected Area fell into four groups according to their TCE concentrations. However, the two groups with the highest concentrations were combined due to the limited number of locations at those levels of detection. Based on the foregoing, "Group" levels were established for the three distinct groups as follows:

- Group 1 – Properties with historic detected TCE concentrations in residential (pre-treatment) groundwater ranging between 130 ug/L and 200 ug/L.
- Group 2 – Properties with historic detected TCE concentrations in residential (pre-treatment) groundwater ranging between 50 ug/L and 130 ug/L.
- Group 3 – Properties with historic detected TCE concentrations in residential (pre-treatment) groundwater ranging between 5 ug/L and 50 ug/L.

Based on the three Groups, an approach was developed to assess whether properties located within the Affected Area exhibit the potential for VI to represent a complete migration pathway at each location. As part of the development of this approach, and in consultation with USEPA, a chart was developed to graphically illustrate the geographic location of the properties within the Affected Area and the associated maximum historic TCE concentrations. The chart, presented as Figure 3-12 in the RI/FS Work Plan, and included in Appendix B, depicted maximum historic TCE concentrations detected in private water wells when viewed from east to west through the Affected Area along Church Road and also when viewed from south to north along South Mountain Boulevard along the western portion of the Affected Area. The following was observed based on these data and findings:

- 9 properties located in the middle portion of the Affected Area fall within the horizontal boundary for Group 1, where 7 of the 9 properties had historic TCE concentrations within the concentration range for Group 1 and 2 properties had concentrations below that concentration range. The area that bounds these 9 properties is hereinafter referred to as Area 1.

- 27 properties located in the eastern and western portions of the Affected Area fall within the horizontal boundaries for two Group 2 portions of the chart, where 10 of the 15 properties available for sampling had historic TCE concentrations within the concentration range for Group 2, and 5 properties had concentrations below that concentration range. The area that bounds these 27 properties is hereinafter referred to as Area 2.

- 38 properties at the far eastern and western portions of the Affected Area fall within the horizontal boundary for the four Group 3 portions of the chart, where all 12 of the 12 properties sampled had historic TCE concentrations within the concentration range for Group 3. The area that bounds these 38 properties is hereinafter referred to as Area 3.

Figure 3-13 in the RI/FS Work Plan depicted the approximate geographic boundaries for the Area 1, Area 2, and Area 3 study areas, and the historic TCE concentrations within the Affected Area. A copy of this figure is provided in Appendix B.

The following sampling approach for each Area, and the number of properties to be sampled in each Area, was proposed in the RI/FS Work Plan and approved by USEPA:

- Area 1 – collect a shallow groundwater sample, 2 sub-slab soil gas samples from 2 locations, 2 indoor air, and 1 outdoor ambient air sample from each of 9 properties under appropriate seasonal conditions (i.e., heating season). One indoor air sample will be collected from the basement or crawl space (if present, such as at a mobile home) and the second indoor air sample will be collected from the first occupied floor of the structure during each round. If the structure on the property is a mobile home, soil gas samples will be collected in place of the sub-slab soil gas samples.

- Area 2 – collect a shallow groundwater sample and 2 sub-slab soil gas samples from 2 locations from each of 27 properties under appropriate seasonal conditions (i.e., heating season). If the structure on the property is a mobile home, soil gas samples will be collected in place of the sub-slab soil gas samples.

- Area 3 – collect a shallow groundwater sample and 2 sub-slab soil gas samples from 2 locations from each of 10 randomly selected properties under appropriate seasonal conditions (i.e., heating season). The 10 randomly selected properties represent 25 percent of the 38 properties in Area 3. If the structure on the property is a mobile home, soil gas samples will be collected in place of the sub-slab soil gas samples. For any non-residential properties, the number of samples and their locations will be determined based upon field conditions, applicable guidance, and in consultation with USEPA.

Deviations from the proposed and approved sampling approach are discussed in the following section.

2.3.2 Vapor Intrusion Field Sampling

For each of the properties proposed for sampling, an access agreement was provided to the property owner to secure permission for the proposed sampling activities. For those property owners that granted access to FWEC, sampling was performed in accordance with the RI/FS Work Plan and the property access agreement. In light of the great eagerness of the community for more immediate information on the potential risks due to vapor intrusion, the consensus reached by FWEC and USEPA was to investigate the potential for ongoing vapor intrusion as quickly as possible. Therefore, the VI investigation activities were performed as soon as practical following receipt of signed access agreements. Due to the timing of the RI/FS Work Plan approval, and execution of the access agreements by homeowners, the majority of the VI sampling was not performed during the heating season, which is the preferred timeframe for VI sampling. The majority of the VI sampling was performed from May through September 2010, with some additional sampling performed in January 2011.

Prior to implementation of the VI field sampling activities, a questionnaire was provided to the property owners and an inventory of household chemicals and "do-it-yourself" products and property owner activities was conducted at least one week prior to the property-specific sampling event. The questionnaire and inventory were used to evaluate the potential for property owner sources of contaminants to be present indoors that could interfere with the VI sampling results. Temporary relocation of such products and airing of the structure was performed prior to conducting the sampling program. The VI investigation also included collecting property-specific data relevant to the VI investigation; property-specific data includes information such as the presence of radon mitigation systems, septic systems and underground tanks.

The following summarizes and Figure 2-1 depicts the sampling activities completed during the VI investigation, based on access granted by property owners and consultation with USEPA:

- Area 1 – 11 shallow groundwater or surface water samples (including 1 duplicate), 11 sub-slab soil gas samples, 15 indoor air samples (including 1 duplicate), 7 outdoor ambient air samples and 2 soil gas samples were collected from 8 properties in Area 1. Of the 9 properties identified in Area 1, one (1) property was not sampled due to the property owner not granting access to the property.

- Area 2 – 28 shallow groundwater or surface water samples (including 1 duplicate), 27 sub-slab soil gas samples (including 3 duplicates), 2 indoor air samples, 1 outdoor ambient air sample and 1 soil gas sample were collected from 20 properties in Area 2. Of the 27 properties identified in Area 2, eight (8) properties were not sampled due to the property owners not granting access to the property. However, one property just outside of Area 2 was sampled and the data are included with the Area 2 data.

- Area 3 – 16 shallow groundwater or surface water samples (including 2 duplicates), 25 sub-slab soil gas samples (including 1 duplicate), and 1 soil gas sample were collected from 9 properties in Area 3. Eleven (11) properties in Area 3 were identified for sampling to achieve the RI/FS Work Plan objective of sampling 10 properties in Area 3. However, two (2) of these properties were not sampled due to the property owners not granting access to the property.

Shallow groundwater, surface water, soil gas and air samples were analyzed for the analytical parameters listed in Table 3-1 of the RI/FS Work Plan, including VOCs and select semi-volatile organic compounds (SVOCs). At the completion of the VI investigation, the analytical results were provided to the individual property owners. On November 18, 2010, the results of the VI investigation were presented to the community at a public meeting. Copies of the presentation materials are provided in Appendix D.

Based on the evaluation of the VI data, and in consultation with USEPA, a VI mitigation system (active venting) was installed in July 2011 at one residence where VI could potentially pose a human health risk. Based on vapor intrusion guidance available at the time of the 2010 vapor intrusion investigation, and in consultation with USEPA, a vapor intrusion mitigation system was also installed at a second residence as a precautionary measure in 2011. These two residences are noted to have site-specific conditions that promoted VI. Specifically, one of these properties was the location of a natural spring which provided a preferential pathway for volatile constituents in the groundwater to migrate up to the building foundation. The other property had a leaky well and pump system that caused the sub-slab area at the building to be saturated with groundwater extracted from the underlying water-bearing zone. These conditions are not known to be present in the rest of the Affected Area. Details of the VI mitigation systems are documented in reports submitted to USEPA in August 2011 (Clean Vapor, 2011a and 2011b). Given the installation and operation of these systems, no VI constituents (i.e., TCE) currently pose an inhalation or other risk to the occupants.

2.4 Surface Geophysical Surveys

Surface geophysical surveys included electrical resistivity and seismic refraction surveys. The objectives of the surface geophysical surveys were to provide data about subsurface stratigraphy, the occurrence of groundwater, and depth of bedrock to determine optimal well placements. These data were collected prior to conducting intrusive field activities, such as advancement of borings and installation of monitoring wells, to supplement the current understanding of stratigraphy and groundwater occurrence.

Surface geophysical surveys were proposed at the former vapor degreaser area, former Finish Paint Building, former Solvent Building, former Paint Storage Building, and at 17 transect locations within the Affected Area. The original proposed location for each of the transects was identified on Figures 3-1 through 3-3 of the RI/FS Work Plan. Copies of these figures are provided in Appendix B. Due to property access restrictions and topographic constraints, there were minor deviations from the geophysical survey transects originally proposed in the RI/FS Work Plan. In addition, one proposed transect in the Affected Area could not be completed due to access not being granted by the property owner.

Appendix E presents the results of the surface geophysical survey activities, including figures documenting the surveyed location of each of the completed transects. The results of the geophysical survey were used to refine the boring and monitoring well locations originally proposed in the RI/FS Work Plan. Revised locations for borings and monitoring wells were identified and submitted to USEPA Region 3 personnel for review and approval. Borings and monitoring wells discussed in subsequent sections of this report were installed at the USEPA-approved locations. At some transect locations, due to technical limitations and/or the depth and composition of the overburden, the surface geophysical surveys were inconclusive with respect to subsurface stratigraphy and the depth to bedrock; these limitations are discussed in Appendix E.

2.5 Direct-Push Soil Profiling with Direct Sensing Tools

Direct-push soil profiles were collected at and near the location of the former vapor degreaser, Finish Paint Building, Solvent Building, and Paint Storage Building to evaluate subsurface soil and groundwater conditions in the overburden stratigraphic unit and characterize the nature and extent of contamination, if present, at these potential/known sources of contamination.

Direct sensing tools, including a membrane interface probe (MIP) in conjunction with an electric conductivity (EC) probe, were used to investigate soil and shallow groundwater in the direct- push boring locations. The MIP system provided real-time, *in situ*, qualitative data on the presence of VOCs in the subsurface utilizing an electron capture detector (ECD), a flame ionization detector (FID), and a photo-ionization detector (PID). The FID is most responsive to straight-chained hydrocarbons such as methane; the PID is most responsive to aromatic hydrocarbons such as benzene, toluene, ethylbenzene, and xylenes (BTEX); and the ECD is most responsive to chlorinated compounds such as TCE. The EC probe provides real-time stratigraphic data to supplement the MIP data.

The former vapor degreaser, Finish Paint Building, Solvent Building, and Paint Storage Building sample locations are shown on Figure 2-2A. MIP/EC direct sensing tools were advanced at a total of 54 profiling locations. Twenty-two soil profiles were collected at and near the former vapor degreaser, and thirty-two soil profiles were collected near the former Finish Paint Building, Solvent Building, and Paint Storage Building.

Field observations, activities, and procedures utilized during the collection of each soil profile were recorded by the Tt field personnel. Based on a review of the real-time screening data, confirmatory soil and groundwater samples were collected at select MIP profiling locations. A total of 9 soil samples (including 1 duplicate) and 3 groundwater samples (including 1 duplicate) were collected from the MIP profiling locations. Results from the direct push soil profile investigation activities are presented in Section 4.6.

2.6 Groundwater Screening Evaluation

Direct-push groundwater sampling using the Hydropunch® technology was planned at 16 locations within the SIPs to assess groundwater migration pathways, to identify the appropriate depth interval to install well screens during overburden monitoring well installation, and to assist in defining the nature and extent of groundwater containing elevated concentrations of Site contaminants in Site exposure media.

Due to geologic conditions encountered, advancing the Hydropunch® tooling using direct-push technology was not possible at all of the proposed locations for the groundwater screening investigation. In order to complete the groundwater screening investigation, a rotosonic drill rig was mobilized to the Site to collect additional groundwater screening samples at locations that could not be sampled using Hydropunch®. In total, 9 borings were advanced using Hydropunch® technology, and 6 borings were advanced using sonic drilling techniques. The locations of these borings are designated as GWE-HP## and shown on Figure 2-2B.

Based on conditions observed during groundwater sampling, including depth to groundwater, headspace PID readings, soil type, and visual and olfactory observations, up to 3 groundwater samples were collected from each location. A total of 27 groundwater samples (including 3 duplicates) were collected from 14 of the 15 boring locations. At location HP-10, multiple attempts were made to collect a groundwater sample; however, refusal occurred at depths ranging from 14 to 18.5 feet bgs, and groundwater was not encountered. A subsequent attempt was made to collect a groundwater sample at this location using sonic drilling techniques. The boring was advanced to the depth of bedrock, approximately 65 feet bgs, but no water was encountered and thus no sample collected. Field observations, activities, and procedures utilized during the advancement of each soil boring and associated groundwater sampling were recorded by the Tt field personnel. Results from the groundwater screening evaluation are presented in Section 4.7.

2.7 Borehole and Monitoring Well Installation

Exploratory borings, overburden and bedrock monitoring wells were installed in accordance with the procedures outlined in the RI/FS Work Plan. Well locations and construction details were submitted to USEPA for review and approval, and installation commenced only after USEPA approval was obtained. The following sections provide details on the installation of soil borings and monitoring wells completed during the RI field investigation.

2.7.1 Exploratory Borings

Five exploratory borings (EB) were advanced at the former FWEC Facility to fulfill select data needs and PQOs described in the RI/FS Work Plan. The locations of these borings are shown on Figure 2-2B. One exploratory boring, EB-01, was advanced near the former vapor degreaser as an up-dip boring to characterize the bedrock geology and identify potential groundwater and contaminant migration pathways. Rock coring and downhole geophysical techniques, as discussed in Sections 2.7.2 and 2.7.3, respectively, were used to collect data about the strike and dip of bedding planes, fractures, and joints, identify their relative transmissivity and/or water-bearing characteristics, confirm the regional geology and hydrogeology, and define the Site-specific geology and hydrogeology.

An additional exploratory core, MD-01, was advanced in the vicinity of the former vapor degreaser. The location of this core was based on the results of the direct push boring investigation. This core was advanced to obtain rock core samples for completion of the bedrock matrix diffusion evaluation, discussed in Section 2.7.2. MD-01 was advanced to a depth of 50 feet into bedrock, approximately 95 feet bgs.

Three additional exploratory borings, EB-02, EB-03 and EB-04, were advanced at the southern portion of the former FWEC Facility property to obtain data about the bedrock geology and identify potential groundwater and contaminant migration pathways. The locations of these borings are depicted on Figure 2-2B. Rock coring was performed at EB-03 and EB-04, and downhole geophysical techniques were utilized at EB-02, EB-03 and EB-04 to collect data about the strike and dip of bedding planes, fractures, and joints, as well as identify their relative transmissivity and/or water-bearing characteristics. EB-02, EB-03 and EB-04 were advanced to depths of approximately 168 feet bgs, 199 feet bgs and 160 feet bgs, respectively.

Exploratory boring EB-01, EB-03 and MD-01 were subsequently converted into bedrock monitoring wells. EB-02 and EB-04 were lined with blank liners for potential future use as monitoring or extraction wells.

2.7.2 Rock Coring and Matrix Diffusion Evaluation

Rock cores were collected at the following locations: MD-01, EB-01, EB-03, EB-04, RMW-01D, RMW-02D, RMW-03S, RMW-03D, RMW-9D, RMW-10D and RMW-12D. Based on the RI/FS Work Plan, the criteria for terminating each of the coreholes was a rock quality designation (RQD) of 90% for 20 continuous feet of the borehole. Based on results observed at EB-04, where contamination was detected within bedrock zones having RQDs greater than 90%, subsequent cores (i.e., RMW-03D, RMW-10D, and RMW-01D) were advanced beyond the depth at which the 90% RQD criteria was achieved. Table 2-1 summarizes the RQD data for the rock cores. The rock cores were evaluated to determine rock type, rock formation contacts, and fractures. The lithologic description of the rock cores were logged and a PID was used to screen the rock cores for the presence of VOCs. Core logs for each of these locations are provided in Appendix F.

At one coring location, MD-01, located in the vicinity of the former vapor degreaser, a matrix diffusion evaluation was performed to evaluate the presence and nature of VOC contamination that may have diffused into the primary porosity (matrix) of the bedrock from its secondary porosity (fractures). MD-01 was chosen for this evaluation as it was in an area of higher groundwater contamination and therefore had an increased likelihood of demonstrating matrix diffusion and providing quantifiable results. Forty-four (44) rock samples were collected from the rock cores obtained from MD-01. The rock samples collected from the core targeted fracture intervals observed upon recovery of the rock core. Samples were provided to Stone Environmental, Inc., for performance of the matrix diffusion evaluation, which included: rock sample trimming, crushing and preservation; microwave assisted extraction (MAE) of water from the rock matrix; and analysis of the water for the presence of VOCs. Quality control samples (field duplicates, equipment blanks, trip blanks, etc.) were also collected and analyzed to support the evaluation of analytical results of the water samples. Four intact core samples were also collected for physical property analysis (bulk density, porosity and fraction of organic carbon). Analytical and physical property data were used to calculate rock pore water concentrations. Results from the matrix diffusion investigation are presented in Section 4.11. Detailed information on the coring, analytical and data evaluation methods and activities is provided in Appendix G.

2.7.3 Downhole Geophysical Logging

Downhole geophysical logging was performed at the following locations:

- EB-01 – up-dip exploratory boring near the former vapor degreaser;
- EB-02, EB-03 and EB-04 – exploratory borings in the southern portion of the former FWEC Facility property;
- MD-01 – matrix diffusion boring near the former vapor degreaser; and,
- RMW-01D, RMW-02D, RMW-03D, RMW-03S, RMW-06D, RMW-07D, RMW-08D, RMW-09D, RMW-10D, RMW-11D, RMW-12D, RMW-13D, RMW-14D – bedrock monitoring well locations in the SIPs and Affected Area.

The objective of the downhole geophysical logging was to obtain data regarding bedrock lithology and the orientation of bedding planes and fractures, as well as to identify transmissive fractures in the bedrock potentially acting as contaminant migration pathways. The results of the downhole geophysical logging was used as a basis to identify select discrete fracture zones for groundwater sampling using packer assemblies, as discussed in Section 2.7.4.

The following borehole geophysical logging methods, as approved by USEPA, were employed to acquire the data from each of the bedrock boreholes: Fluid Temperature (TMP), Fluid Conductivity (FLC), Single Point Resistivity (SP), Short Normal Resistivity (SNR), Long Normal Resistivity (LNR), Natural Gamma Logging (NG), Caliper (CAL), Heat Pulse Flowmeter (HPF), Borehole Acoustic Televiewer (ATV) and Neutron Porosity (NP). The HPF collected measurements under both pumping and non-pumping conditions. Borehole geophysical data were digitally acquired in the bedrock boreholes using a borehole logging system capable of digitally acquiring borehole geophysical data. Downhole geophysical logs for each of the bedrock boreholes are provided in Appendix H.

Downhole video camera surveys were performed in the boreholes advanced at locations MD-01, EB-04, RMW-02D, RMW-03S, RMW-09D, RMW-11D, RMW-13D, and RMW-14D, to provide direct observations of borehole characteristics. These boreholes were selected based on their geographic location, depth, and observations made during advancement of the borehole. In addition, a downhole video camera survey was performed at the former FWEC Facility production well, now identified as MW-5, to obtain well construction information and evaluate an obstruction identified at depth within the well in 2009.

2.7.4 Groundwater Packer Sampling

Groundwater sampling using packer assemblies was performed at each the borings advanced into bedrock. Based on interpretation of the core logs, when available, and the downhole geophysical data, recommendations for packer testing intervals within each borehole were prepared and submitted to USEPA for review and approval. Upon receipt of USEPA's approval of the packer test recommendations for each borehole, the packer tests were completed as described in the RI/FS Work Plan. Results from the packer testing groundwater samples are presented in Section 4.8.

In addition, observations during the packer testing were used to identify transmissive fractures in bedrock which might potentially act as contaminant migration pathways. These data, in conjunction with the groundwater sample results, were used to help identify the appropriate screen depths and interval(s) for the bedrock monitoring wells.

2.7.5 Overburden Monitoring Well Installation

Nineteen monitoring wells were installed in the overburden to obtain groundwater elevation data, assess potential migration pathways of groundwater at the Site, and define the nature and extent of groundwater potentially containing elevated concentrations of Site contaminants. The following table identifies the overburden wells installed as part of the RI activities and their total depths:

Overburden Well ID	Depth (feet bgs)	Overburden Well ID	Depth (feet bgs)
RMW-01S-1	47.0	RMW-08S	80.0
RMW-01S-2	115.0	RMW-09S-1	55.0
RMW-02S-1	48.0	RMW-09S-2	67.0
RMW-02S-2	70.0	RMW-10S	120.0
RMW-04S-1	45.0	RMW-11S	70.0
RMW-04S-2	70.0	RMW-12S	40.0
RMW-04S-3	135.0	RMW-13S-1	55.0
RMW-05S	119.0	RMW-13S-2	130.0
RMW-06S	120.0	RMW-14S	34.0
RMW-07S	50.0		

Table 2-2A2 provides additional construction details for the overburden wells, and the locations of these wells, selected in consultation with USEPA as discussed previously, are depicted on Figure 2-2B.

The general approach for installation of the overburden wells at each of the selected locations was as follows:

1. At each of the proposed overburden well locations, a soil boring was advanced using hollow stem auger (HSA) drilling methods, to approximately the top of the bedrock surface.
2. PID readings were taken as each soil boring was advanced.
3. Split spoon samples were collected at select intervals in the borehole. In general, 2-foot split spoon samples were collected for the first six (6) feet of each boring, and then at approximately 5-foot intervals for the remainder of the borehole to provide general geologic profiles at each borehole location. Based on field observations, additional split spoon samples were collected at select locations.
4. The augers were left in the boreholes while the data was evaluated to prepare a recommendation for overburden well installation to minimize potential for cross-contamination within the borehole.
5. Boring logs were prepared to document the geologic conditions at the specific drilling location.
6. A recommendation for construction of one or more overburden monitoring wells at the selected location was prepared based on evaluation of the geology, field observations and, where applicable, surface geophysical results and/or groundwater grab samples.
7. The well construction recommendations were provided to USEPA for review and approval as soon as practical after achieving the desired depth, typically within 1-2 days.

8. The recommendations for well construction were reviewed with USEPA as soon as possible after submittal, and upon receipt of USEPA's approval, the overburden monitoring wells were installed in accordance with the approved well construction recommendation.

The sequence of overburden well construction activities discussed above was completed as quickly as possible to minimize potential for cross-contamination. Overburden monitoring wells were constructed using 2 inch PVC screen and casing. Appendix F provides soil boring logs for each overburden borehole location, and Appendix I provides well construction diagrams for each of the overburden wells.

2.7.6 Bedrock Monitoring Well Installation

Sixteen monitoring wells, including four (4) multiport Flexible Underground Technologies (FLUTe) wells, were installed in bedrock to obtain groundwater elevation data, assess potential migration pathways of groundwater at the Site, and define the nature and extent of groundwater potentially containing elevated concentrations of Site contaminants. The following table identifies the bedrock wells installed as part of the RI activities and their total depths:

Bedrock Well ID	Depth (feet bgs)	Bedrock Well ID	Depth (feet bgs)
MD-01	60.0	RMW-07D	156.0
EB-01	180.0	RMW-08D	143.0
EB-03	138.0	RMW-09D (FLUTe)	245.0
RMW-01D (FLUTe)	318.0	RMW-10D	215.0
RMW-02D	178.0	RMW-11D (FLUTe)	160.0
RMW-03S	100.0	RMW-12D	77.0
RMW-03D	214.0	RMW-13D	198.0
RMW-06D (FLUTe)	319.0	RMW-14D	81.0

Table 2-2B provides additional construction details for the bedrock wells, including the sample zones for the Flexible Liner Underground Technology (FLUTe) wells, and the locations of these wells, selected in consultation with USEPA, are depicted on Figure 2-2B.

The general approach for installation of the bedrock wells at each of the selected locations was as follows:

1. At each of the proposed bedrock well locations, outer steel casing was advanced approximately 10 feet below the bedrock surface and grouted into place to prevent cross-contamination between the overburden and bedrock.

2. At select locations, including MD-01, EB-01, EB-03, EB-04, RMW-01D, RMW-02D, RMW-03S, RMW-03D, RMW-9D, RMW-10D and RMW-12D, bedrock cores were collected and RQDs were calculated to determine the termination depth of the bedrock borehole, as discussed in Section 2.7.2.
3. For locations where coring was not performed, the termination depth of the borehole was determined from an interpretation of the geology and the coring results from adjacent boreholes.
4. Downhole geophysical data were collected at each of the boreholes, as discussed in Section 2.7.3.
5. Packer testing was performed at each of the boreholes, as discussed in Section 2.7.4.
6. Based on evaluation of the packer test data, and other data available at each borehole location, a recommendation was prepared to advance the borehole deeper, or to install a conventional bedrock monitoring well or a multiport FLUTe well at each location.
7. The recommendation were provided to USEPA for review and approval as soon as practical after completion of the borehole testing.
8. As soon as possible after receipt of USEPA's approval of the recommended action, the monitoring well was installed in accordance with the approved recommendation, or the borehole was advanced deeper and additional testing was performed starting with Step 4 above.

Conventional bedrock monitoring wells were constructed using 2 inch PVC screen and casing. Water FLUTe wells were installed at 4 locations, RMW-01D, RMW-06D, RMW-09D and RMW-11D. Appendix F provides boring logs for each bedrock borehole locations logged, and Appendix I provides well construction diagrams for each of the bedrock monitoring wells.

2.8 Surface Water, Sediment, and Pore Water Sampling

Surface water and sediment sampling were conducted at the former FWEC Facility, the SIPs, and the Affected Area. Pore water sampling also was conducted at the SIPs and the Affected Area. The RI/FS Work Plan proposed 29 surface water and sediment sampling locations and 9 pore water sampling locations. On April 27, 2011, a Site Reconnaissance was performed in tandem with representatives from USEPA and United States Fish and Wildlife Service (USFWS) Biological Technical Assistance Group (BTAG). During the Site Reconnaissance, minor modifications to the proposed sample locations were made, and one additional surface water and sediment sample location and three additional pore water sample locations were added. The locations of the USEPA-approved surface water, sediment and pore water samples are shown on Figure 2-2B. Results from the surface water, sediment and pore water sampling are presented in Section 4.9.

2.8.1 Installation of Stream Gages

Eight stream gages were installed in Watering Run. A licensed land surveyor obtained horizontal and vertical locational data for the stream gages. The locations of the stream gages, as shown on Figure 2-2B, include:

- One near the groundwater treatment system present at the former FWEC Facility;
- One in the southern portion of the former FWEC Facility property;
- Two within the SIPs; and
- Four within the Affected Area.

The stream gages were used to obtain surface water elevations data from Watering Run and assess the interaction between surface water and groundwater.

2.8.2 Surface Water and Sediment Sampling

Surface water samples were collected twice at each sample location as described below, with one round collected during high flow conditions and one round collected during low flow conditions in accordance with the RI/FS Work Plan. One round of sediment samples was collected during low flow conditions, after the collection of the surface water sample for that location. Supplemental sediment sampling to support the SLERA was performed at the outflow of the WWTP, which is discussed in FCR-12. In addition, an additional sediment sample was collected from the on-site pond (location SD02) in April 2016 for analysis of total organic carbon (TOC).

Due to a lack of flow data for Watering Run, a hydrograph could not be developed for the stream. The criteria for the high flow conditions, sampling within 2-days of a rain event of 1-inch or more over a 24-hour period, and the criteria for low flow conditions, a period of no precipitation lasting at least 7 days, were developed in consultation with USEPA and presented in Section 3.1.7 in the USEPA-approved RI/FS Work Plan.

2.8.2.1 High Flow Conditions Sampling

During the RI field investigation, precipitation data from the National Oceanographic and Atmospheric Administration (NOAA) weather station located nearest to the Site at the Wilkes-Barre/Scranton Airport station, located in Avoca, Pennsylvania, was utilized as the source of the precipitation data in order to determine when the high flow criterion was met. During the evening hours on May 3, 2011, 1.2 inches of rainfall were reported. The high flow surface water sampling event took place on May 5, 2011, during which 32 surface water samples were collected, including two duplicate samples.

2.8.2.2 Low Flow Conditions Sampling

For low flow condition sampling, surface water, sediment, and pore water sampling was performed after confirmation of a period of minimal precipitation lasting at least seven days at the Wilkes-Barre/Scranton Airport. Reported rainfall for the 8-day period ending August 24, 2011 was a total of 0.01 inches (reported on August 19, 2011), with no other precipitation reported during this period. Surface water and sediment sampling was initiated on August 24, 2011, and completed on August 25, 2011. During this sampling event, 30 surface water samples were collected, including two duplicate samples. Due to low flow conditions, there was inadequate flow to collect samples at two of the proposed locations, SW-04 and SW-05. A total of 32 sediment samples, including two duplicate samples, were collected during the low flow condition sampling event.

2.8.2.3 Supplemental Sediment Sampling

During the initial data screening to support the SLERA, concentrations of select metals and PAHs were detected above individual sediment quality screening levels in the most downstream sample location in the WWTP outflow channel. As presented in FCR-12, five additional sediment samples were collected on October 13, 2014 to further delineate these impacts.

2.8.2.4 Additional Surface Water and Sediment Sampling

In April 2016, as outlined in FCR 14, additional surface water and sediment samples were collected from location SW/SD02 for analysis of chromium (total and/or dissolved) and hexavalent chromium, as well as total organic carbon (TOC), total solids, ORP, and pH in the sediments. As this location had indicated the highest level of total chromium during the previous events, the surface water and sediment were re-sampled to evaluate the potential for speciation to hexavalent chromium.

2.8.3 Pore Water Sampling

Passive diffusion bag samplers (PDBS) were placed into the stream sediments at the selected locations on August 25, 2011 to collect pore water samples during low flow conditions. Each PDBS was installed in the stream sediments after collection of the surface water and sediment samples for each location. The PDBS remained in the stream bed for approximately 21 days and were then removed for sample collection and laboratory analysis. A total of 13 pore water samples, including one duplicate, were collected from 12 locations using PDBS on September 15, 2011.

2.9 Hydraulic Testing

A short-term step-drawdown test was performed on December 13, 2012 at monitoring well RMW-01D, located on the CertainTeed facility, to obtain preliminary aquifer hydraulic characteristics. The results from the step-drawdown test are discussed in Section 3.5.2. Following this initial test, it was determined that additional aquifer testing would be deferred to the FS, at which time such testing could be performed to provide the most applicable data for the potential groundwater remedies under consideration.

2.10 Elevation Measurements

Three synoptic rounds of groundwater elevation measurements were conducted, on May 23, 2013, September 9, 2013, and April 14, 2014, in conjunction with the three groundwater sampling events discussed in Sections 2.11.6, 2.11.7, and 2.11.9.

Surface water elevation measurements from stream gages were collected in conjunction with the second and third round of groundwater elevation measurements on September 9, 2013 and April 14, 2014, respectively.

The groundwater and surface water elevation data were used to:

- Identify groundwater flow vectors under seasonal base flow conditions;
- Collect sufficient data to prepare potentiometric surface maps; and
- Evaluate the interaction between groundwater and surface water at various locations throughout the Site and assess the potential for impacted groundwater to discharge to surface water.

Measured groundwater and surface water elevations, where access was provided by the property owners, are summarized in Table 2-33. The groundwater elevation data were consistent with the prior understanding of groundwater conditions at the Site. Site-specific hydrogeology is discussed further in Section 3.5.2.

2.11 Groundwater Sampling

Field investigation activities included the collection of groundwater samples from the existing monitoring wells from site investigation activities prior to the RI, where access was provided by the property owners, and the new monitoring wells installed during the RI field activities. The following sections discuss each of the groundwater sampling events performed during the RI field activities. Results from the various groundwater sampling events are presented in Section 4.10.

2.11.1 Grab Groundwater Samples at RMW-04S-2 and RMW-14S

Groundwater samples were collected from RMW-04S-2 and RMW-14S on May 10, 2011 and June 15, 2011, respectively. These samples were collected to obtain preliminary information on contamination levels at these locations to determine if additional wells should be installed. These samples were collected as grab samples using bailers, rather than using low-flow sampling techniques used in subsequent groundwater sampling events.

2.11.2 Interim Sampling at Well Clusters RMW-02S and RMW-04S

Interim groundwater samples were collected from RMW-02S-1, RMW-02S-2, RMW-04S-1 and RMW-04S-2 on December 21, 2011, to evaluate groundwater conditions in this area and assess the need for an additional deeper monitoring well. These samples were collected using low-flow sampling techniques. Purge sheets for this sampling event are included in Appendix J.

2.11.3 Interim Overburden Groundwater Sampling

Groundwater samples for VOC analysis were collected from 16 newly-installed overburden monitoring wells from April 10 to 12, 2012, to evaluate the general overburden groundwater conditions and assess the need for additional overburden and/or bedrock wells. MW-18, located at the southern boundary of the former FWEC Facility, also was sampled during this sampling event. These samples were collected using low-flow sampling techniques. Purge sheets for this sampling event are included in Appendix J.

2.11.4 Interim Sampling at FLUTe Well RMW-06D

Two rounds of groundwater samples were collected from the seven sampling zones in FLUTe well RMW-06D, on December 20, 2012, and January 30, 2013. The first round was collected to determine the vertical profile of contamination to assist in the determination of the optimal construction of the other FLUTe wells in the valley. The vertical contamination profile obtained during the initial sampling event showed similar TCE concentrations in multiple fracture zones, suggesting that the discrete fracture zones may not have been adequately purged following the installation of the FLUTe liner. Subsequently, FWEC performed an evaluation of the FLUTe purging and sampling procedure independent of the RI activities. Based on this study, subsequent FLUTe sampling events used a slightly modified sampling procedure (i.e., additional initial purging of the FLUTe zones). FLUTe well RMW-06D was purged using the modified sampling procedure and resampled on January 30, 2013. The results from this sampling event appeared to provide a more representative vertical groundwater contamination profile.

2.11.5 Interim Sampling at FLUTe Wells RMW-01D, RMW-09D and RMW-11D

Interim groundwater samples were collected from FLUTe wells RMW-01D (3 sampling zones), RMW-09D (6 sampling zones) and RMW-11D (3 sampling zones) on April 17 to 18, 2013. As discussed in section 2.11.4, this sampling event used the modified FLUTe sampling procedure. The primary objective of this sampling event was to verify that the FLUTe wells were adequately developed to provide accurate vertical contaminant profile data, prior to performance of the planned full round of groundwater sampling for the RI.

2.11.6 Groundwater Sampling Round 1

Upon completion of installation of the new monitoring wells, a round of groundwater samples was collected from the monitoring well network from May 6 to 23, 2013. The list of wells to be sampled and the parameters to be analyzed from each well were submitted to and approved by USEPA in FCR-08 prior to performing the sampling event. A copy of FCR-08, including the sampling table, is provided in Appendix C. As noted on the sampling table, samples from 11 monitoring wells underwent analysis for the presence of Dehalococcoides ethenogenes to support an evaluation of natural attenuation processes. In addition to the analytical parameters identified in the FCR, water quality indicator parameters including pH, temperature, specific conductivity, dissolved oxygen, turbidity, and oxidation-reduction potential (Eh) were monitored in the field during the groundwater sampling, as discussed in the RI/FS Work Plan. Purge sheets for this sampling event are included in Appendix J.

2.11.7 Groundwater Sampling Round 2

A second round of groundwater sampling was conducted from September 10 to 20, 2013, to evaluate seasonal variations in groundwater conditions. As with the first round of sampling, an FCR, FCR-09, identifying wells to be sampled and parameters to be analyzed for each well, was submitted to and approved by USEPA prior to implementing the sampling activities. A copy of FCR-09 is provided in Appendix C. Purge sheets for this sampling event are included in Appendix J.

2.11.8 Supplemental Groundwater Sampling Event

Following the Round 2 sampling event, supplemental samples were collected on October 14, 2013 and October 23, 2013 from select sentinel wells and seeps to provide current data to verify the periphery of the extent of impacted groundwater.

2.11.9 Groundwater Sampling Round 3

During review of the laboratory results from the Round 1 and Round 2 sampling events, significant deviations were observed in the reported concentrations of 1,4-dioxane, particularly from samples associated with the FLUTe wells. As a result, an additional round of sampling was conducted April 7 to 11, 2014. The rationale for the additional sampling event, wells sampled, and parameters analyzed were presented in FCR-10, which was submitted to and approved by USEPA prior to implementation, and is included in Appendix C. During this sampling event, a modified FLUTe sampling procedure was implemented, extra precautions were taken to minimize the potential for contamination of samples with 1,4-dioxane from well construction, sampling and/or decontamination materials, and a modified laboratory analytical method was used for the 1,4-dioxane analyses. Blind 1,4-dioxane performance evaluation (PE) samples were also submitted for analysis during this sampling event to provide an additional measure for quality assurance/quality control. Purge sheets for this sampling event are included in Appendix J.

2.11.10 Supplemental Groundwater Sampling at RMW-09S-1 and RMW-09S-2

During review of the results from the Round 3 groundwater sampling event, it was observed that the TCE concentration of 110 ug/L at RMW-09S-1 was significantly different from the prior two sampling events, which had TCE concentrations of 0.26J and 0.09U. To assess whether the Round 3 result may have been anomalous, additional samples were collected at RMW-09S-1 and RMW-09S-2 on October 14, 2014. FCR-13 was submitted to and approved by USEPA prior to collection of the groundwater samples, and is included in Appendix C. Purge sheets for this sampling event are included in Appendix J. The analytical results from the supplemental sampling confirmed that the prior result of 110 ug/L was anomalous or erroneous.

2.11.11 Additional Groundwater Sampling at EB-01

To evaluate the potential for hexavalent chromium speciation in groundwater, an additional groundwater sample was collected in April 2016 from monitoring well EB-01. The sample underwent analysis for total chromium, dissolved chromium, and hexavalent chromium in accordance with FCR 14.

2.12 Land Survey

An aerial flyover and land survey of the former FWEC Facility, SIPs, and the Affected Area was conducted by a licensed Pennsylvania surveyor. The survey included obtaining horizontal and vertical locational data for the newly installed stream gages and monitoring wells, as well as the existing monitoring wells. Monitoring well and stream gage horizontal locations were surveyed to the nearest 0.1 foot, and ground surface elevation and inner casing elevation were surveyed to the nearest 0.01 foot. The survey was prepared in the Pennsylvania State Plane Coordinate System using the North American Datum of 1983 (NAD 83) as the horizontal control and the North American Vertical Datum of 1988 (NAVD 88) as the vertical control.

Global Positioning System (GPS) equipment was used during the field investigation to locate other sampling locations, such as surface water, sediment, direct push and other shallow groundwater sample locations.

2.13 Quality Control During Field Investigation

The following subsections identify the field samples used during the investigation to assess quality control (QC) during sampling procedures. The use of these blank samples assists in assessing whether contamination was introduced into the sampled material from outside sources. QC samples were subjected to the same laboratory analyses as the associated site samples. The results obtained from the analysis of the field procedural blanks were utilized in the evaluation of the usability of the investigation data (see Section 4.2).

2.13.1 Field Equipment Rinsate Blanks

Field equipment rinsate blanks were collected to demonstrate the quality of the decontamination events and to prove that contaminants had not been introduced into the environmental samples by the field equipment. A total of 52 field blanks were prepared for the RI, by pouring DI water over/through the decontaminated or disposable equipment that would later come in contact with the sample material. The water was then collected, preserved as applicable, and sent with the rest of the associated environmental samples, to be analyzed for the same parameters.

2.13.2 Trip Blanks

Trip blanks measure whether aqueous volatile organic samples have been contaminated during collection, transport and/or storage. Trip blanks consisted of three VOA vials filled in the field with DI water and preserved accordingly, which traveled with the associated day's VOC samples from the time of their collection, until their analysis at the laboratory. During this field investigation, a total of 79 trip blanks were shipped with containers containing aqueous samples for VOC analysis. Trip blanks were shipped with groundwater screening evaluation, packer groundwater, surface water, and groundwater samples.

2.13.3 Water Blanks

Two water blanks – one for the source of deionized water used during the August 2011 pore water investigation and one of a potable water source during the April 2014 groundwater event – were collected and analyzed during the RI.

2.13.4 Performance Evaluation Samples

During the April 2014 supplemental groundwater sampling event for 1,4-dioxane, certified PE samples were submitted to the laboratory to provide additional data for quality assurance/quality control evaluation. Two PE samples were submitted to the laboratory with each batch of samples submitted for 1,4-dioxane analysis; a total of eight PE samples were submitted.

2.14 Investigation Derived Waste Characterization and Disposal

Investigation-derived waste (IDW) was generated during the RI/FS field activities and containerized and stored in a secure location on the former FWEC Facility prior to disposal. IDW was characterized prior to disposal and managed as follows:

- Monitoring well purge and development water were treated at the on-site groundwater treatment system and discharged, as approved by USEPA;
- Consumables not contaminated by site contaminants or hazardous materials were disposed as conventional solid waste. Three (3) rolloffs containing 7.59 tons of solid waste were disposed at Keystone Sanitary Landfill in Dunmore, PA.
- Soil and rock cuttings, associated drilling fluids and IDW were containerized in drums and/or frac tanks and disposed off-site and an approved disposal facility. All materials were characterized as non-hazardous. 915 drums, 4,926 gallons of bulk liquid waste, and 3.11 tons of bulk sludge from tank cleanouts were disposed at Environmental Recovery Corp. in Lancaster, PA.

Executed non-hazardous waste manifests and landfill disposal tickets are provided in Appendix K.

2.15 Demobilization

Equipment and personnel were demobilized upon completion of a task (as applicable) and at the conclusion of all field activities. Demobilization included the following activities:

- Restoration of site locations;
- Removal of temporary decontamination pad;
- Staging, inventory and removal of wastes, including IDW, from the Site; and
- Return of rental/leased equipment.

2.16 Data Visualization and Analysis

Investigation data were evaluated using desk-top analysis, 2-D geospatial analysis using GIS technologies and 3DVA using specialty methods and software. The geospatial analysis was performed using numerical algorithms (i.e., kriging) with the results being evaluated and refined using the professional judgment of the technical team for data accuracy as described in Section 6.1 and illustrated on the accompanying exhibits.

2.16.1 2-D Geospatial Analysis

Site-specific and public domain spatial data were gathered and organized in shapefiles and geodatabases as part of the data analysis and map generation to support the RI investigation. The data were imported into ESRI's® ArcMap™ program. Non-georeferenced public domain and historic maps were digitized and georeferenced where possible using known landmarks. Other 2-D geospatial analysis was performed using MVS for specific datasets (i.e., chemistry data interpolation).

2.16.2 3DVA

MVS software developed by C Tech Development Corporation was used to perform 3DVA of Site hydrogeologic data. This software uses kriging geostatistical procedures to calculate the distribution of each parameter in a spatially correct 3-D framework. 3DVA is based on spatially-accurate visualization of actual data versus empirical data, and does not include extrapolation or other predictive interpretations.

The 3DVA process began with confirmation and assessment of project objectives and discussions of key issues to address. The following activities were completed once project objectives were established:

- Development of a project geographic information system (GIS).
- Determination of geostatistical visualization parameters.
- Development of component visualizations (e.g., stratigraphy, lithology, etc.).
- Integrated visualization and analysis.

2.16.3 Database Development

Project data were organized into spreadsheet databases that could be manipulated to construct the electronic data files needed for the visualizations. Data entry development included the creation and maintenance of a project GIS. The project GIS was used in conjunction with the MVS software to manage spatial data. The project GIS facilitated the creation of overlays, development of an understanding of spatial relationships of the project data, and construction of data files used in other elements of the spatial data analysis process.

2.16.4 Determination of Geostatistical Visualization Parameters

Geostatistical visualization parameters were established and evaluated, a critical element of the data analysis process. Geostatistical analyses were based on a number of parameters that controlled how geostatistical estimations (variography and kriging) were performed. Critical geostatistical parameters established included:

- Grid resolution and extent necessary to adequately display the visualized data.
- Whether adaptive or proportional gridding was to be used.
- Ratio of horizontal to vertical anisotropy.
- Whether the data supports log10 transformation.

2.16.5 Development of Component Visualizations

Component visualizations were developed and used to create the integrated site visualizations. The following individual "components" were visualized:

- Topography and aerial photography,
- Geology (i.e., stratigraphy, lithology and competency),
- Hydrogeology (i.e., water table and head elevations), and
- Groundwater contaminant chemistry; specifically for TCE.

Each of the data sets used were geostatistically analyzed independently to determine the unique aspects of each component data set. Independent visualization of each component data set was used to ensure that no artificial bias was introduced into one component's analysis based on the analysis of another component's database.

2.16.6 Integrated Visualization and Analysis

Integrated visualizations, created by combining the component visualizations, were used to support the Site analyses, such as comparison of visualized TCE plume to geology and hydraulic distributions. The integrated visualizations are not the product of a singular integration and kriging of all data types. Rather, each component visualization is the product of kriging a single data type. The component visualizations are then simply viewed and evaluated in unison within a mutually spatially-accurate framework. This ensures that the correlations of physical features and contaminant properties are reflective of Site conditions.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

The following sections provide a summary of the physical characteristics of the Site, including topography, hydrology, climate, land use, geology, hydrogeology and ecological setting. The major findings presented in this section are also included in Section 6.0, Conceptual Site Model.

3.1 Surface Features

3.1.1 Topography

According to the United States Geological Survey (USGS) 7.5-minute topographic quadrangle, ground surface elevation at the former FWEC Facility ranges from approximately 1,600 to 1,630 feet above mean sea level (msl). The former FWEC Facility is located at a surface water drainage divide, with the northern portion of the property draining to the north towards Bow Creek and the central and southern portions of the property draining to the south towards the surface feature that drains into Watering Run.

Regionally, ground surface elevations rise to the east of the former FWEC Facility property and generally slope downward to the north, west, and south of the former FWEC Facility, as depicted on Figure 3-1. Immediately west of the northern portion of the former FWEC Facility and localized to this area, ground surface slopes upward to a plateau-like ridge occupied by the Philips Lighting Facility property. Ground surface slopes radially from the Philips Lighting Facility, consistent with the regional topography.

In the SIPs, localized ground topography is significantly impacted by the industrial development. In general, south of the former FWEC Facility, ground surface elevations slope to the west toward the Affected Area. West of the former FWEC Facility, ground surface elevations generally slope to the south towards the Affected Area.

Overall, ground surface decreases in elevation from approximately 1,620 feet msl at the former FWEC Facility to approximately 1,300 feet msl at the downgradient edge of the Affected Area (Figure 3-1).

3.1.2 Hydrology, Drainage and Wetlands

The headwaters draining into Watering Run flow south-southwest from the eastern portion of the former FWEC Facility, towards the southern property boundary. South of the former FWEC Facility property boundary, Watering Run turns towards the west and generally flows west through the Affected Area, eventually discharging to the Susquehanna River, located approximately 12 miles west of the Site. Currently, the stream has perennial flow resulting from groundwater seeps located along the eastern portion of the former FWEC Facility property and the discharge of treated groundwater effluent from the FWEC GETS. Under natural conditions, Watering Run may exhibit ephemeral or perennial flow characteristics dependent upon the amount of discharge Watering Run receives from groundwater seeps, tributaries, and surface drainage flowing from the ridges north, east and south of Watering Run. Additional discussion of Watering Run, its tributaries and seeps feeding Watering Run is provided in the SLERA.

Figure 3-2 presents the areas at and near the Site identified as wetlands by the National Wetlands Institute (NWI). Based on the NWI map, a small wetland area is located at the northwest portion of the former FWEC Facility, near the former WWTS. A second small wetland area is located southwest of the former FWEC Facility between the Quaker Oats/Gatorade and Bergen Machine facilities. Several additional areas of wetlands are present at and near the Affected Area, primarily within the western portion of the Affected Area, away from the SIPs. Additional discussion of wetland areas at the Site is provided in the SLERA.

3.2 Climate

The Site is located in a temperate region with an average annual temperature of 49.4°F according to a review of average annual temperatures reported by the National Weather Service for the Wilkes-Barre/Scranton Airport in Avoca, PA from 1951 through 2012 (NOAA, 2013). The coolest annual average temperature (47°F) reportedly occurred during 1958. The warmest annual average temperature (53°F) occurred in 2012. Based on National Weather Service data reported for the Wilkes-Barre/Scranton Airport from 1981 through 2010 (NOAA, 2011), the monthly average high of 81.9°F occurs in July and the monthly average low of 18.5°F occurs in January.

Average annual precipitation is 37.1 inches according to a review of average annual precipitation reported by the National Weather Service for the Wilkes-Barre/Scranton Airport in Avoca, PA from 1951 through 2012 (NOAA, 2014). The wettest year reported during the period was 2011 with 60 inches of precipitation. The driest year reported during the period was 1963 with 26.22 inches of precipitation. Based on National Weather Service data reported for the Wilkes-Barre/Scranton Airport from 1981 through 2010 (NOAA, 2011), the average monthly maximum of 4.07 inches of precipitation occurs in September and an average monthly minimum of 2.03 inches occurs in February.

3.3 Demography and Land Use

The Site, including the former FWEC Facility property, is located in Luzerne County, in the northeast portion of Pennsylvania. The Site is located in Mountain Top, Pennsylvania, which is a Census-Designated Place, consisting of Dorrance Township, Fairview Township, Rice Township, Slocum Township, and Wright Township.

Land use near the Site generally consists of a mix of commercial/industrial properties, residential properties, deciduous forest, and roads. Land use at the former FWEC Facility and surrounding properties within Crestwood Industrial Park is deemed industrial. Surface cover at the former FWEC Facility includes asphalt paving, concrete, railroad ballast, rail lines, and soil. Portions of the former FWEC Facility property are forested.

Land use in the Affected Area is primarily residential with some commercial land use along South Mountain Boulevard and a few locations along Church Road, such as a hardware store and a lawn mower repair shop. The majority of the residential land use at the Affected Area consists of single-family homes. Deciduous forest and roads are also present within the Affected Area.

Future land use at and near the Site is anticipated to remain the same, with a mixture of commercial/industrial and residential properties.

3.4 Geology

3.4.1 Regional Geology

The Site is located within the Susquehanna Lowlands physiographic section of the Ridge and Valley physiographic province. The Susquehanna Lowlands physiographic section is characterized by low to moderately high linear ridges and valleys within the Susquehanna River valley. Multiple glacial advances moved over this region during recent geologic history causing the majority of the ground surface in Luzerne County and the area near the Site to be underlain by glacial deposits, comprised primarily of glacial till. The thickness of the glacial till generally ranges from 6 feet to greater than 100 feet thick. Thicker deposits of glacially derived material are typically found within buried valleys (Braun, 2008a; 2008b; 2008c; 2008d).

According to the Surficial Geology Maps for the Wilkes-Barre West, Wilkes-Barre East, Freeland, and White Haven quadrangles, presented in Figure 3-3, the Site is underlain by Wisconsinan Till (Braun, 2008a). The Wisconsinan Till is described as a non-sorted or poorly sorted, unconsolidated deposit containing a wide range of particle sizes, commonly from clay to cobble- or boulder-size, and rounded and/or angular fragments with a clayey, silty, or sandy matrix, with clast composition dependent on the local source bedrock.

Typical rock types within the Susquehanna Lowlands section consist primarily of sedimentary rocks with open and closed plunging folds with narrow hinges and planar limbs (PA DCNR, 2000). The bedrock formations generally strike to the northeast-southwest, consistent with the orientation of the regional geology.

Regional geologic maps for the Wilkes-Barre West, Wilkes-Barre East, Freeland, and White Haven quadrangles, presented in Figure 3-4, indicate the bedrock underlying the glacial till deposits throughout the majority of the Site consists of the Duncannon Member of the Upper Devonian-age Catskill Formation (PAGS, 1981). The Duncannon Member consists of grayish-red sandstone, siltstone, and claystone in fining-upward sequences. Review of the regional geologic studies and maps indicates the Duncannon Member generally dips gently to the southeast at approximately 5 to 10 degrees. The westernmost portion of the Affected Area is underlain by the Sherman Creek Member of the Catskill Formation. The Sherman Creek Member consists of gray-red siltstone and claystone in fining-upward sequences, with minor intervals of gray sandstone. The Mississippian age Pocono sandstone, which is a primary ridge-forming formation, appears to likely be present along the southern edge of the Affected Area, and may represent rocks of the valleys southeastern ridge. The Site is located on the southeast limb of the Berwick anticline. The axis of the Berwick anticline is located approximately 2.5 to 3 miles to the northwest and plunges east-northeast (WCC, 1990).

3.4.2 Soils

Figure 3-5 presents a map of the soil series located at the Site based on a review of the National Resource Conservation Service (USDA, 2008). Twenty-three distinct soil types are identified as occurring at or near the Site. Only those soils which comprise the major soil types or units present at and near the Site are presented below. The majority of the 23 distinct soil types occur as isolated pockets or fragments within a larger area soil series.

The most prevalent soils series at the Site include:

- Basher Soils (Bf);
- Braceville Gravelly Loam (Br);
- Cut and fill land (CF);
- Chenango Gravelly Loam (ChB);
- Chippew Silt Loam (Cl);
- Lackawanna Silt Loam (LB);
- Morris Silt Loam (M);
- Oquaga and Lordstown Silt Loams (Ol and Op);
- Rexford Loam (RB); and
- Wellsboro Silt Loam (Wl and WM).

The Bf series is present at the western boundary of the Affected Area. The Bf soils consist of deep, moderately well drained soils at floodplains. The soils are formed in alluvial deposits derived from reddish sandstone, siltstone and shale bedrock. These soils typically have a dark reddish brown surface layer approximately nine inches thick and are generally present at slopes ranging from 0 to 3 percent grade.

The Br series is present within the Affected Area, south of Watering Run, within the north-central portion of the Affected Area. The Br series consists of somewhat poorly to moderately well-drained soils, generally present along terraces, benches, alluvial fans, and glacial moraines. The soils generally formed from glacial outwash of stratified sand, silt, and gravel and are present at slopes ranging from 3 to 15 percent grade.

The CF series is generally present at the developed properties of the Crestwood Industrial Park. The soil is generally variable, and the extent of the area the soil encompasses is dependent upon the extent of land disturbed during development.

The ChB series consists of well drained soils formed in glacial outwash plains from gravelly outwash material. The soils formed in material sorted by fluvial, or other water-driven processes. The soils are located south of Watering Run, within the central portion of the Affected Area, along Church Road. The soils are generally present along slopes ranging from 3 to 8 percent grade.

The Cl series consists of poorly drained soils, generally present along uplands. The soils were formed from glacial till deposits containing reddish sandstone. The Cl series soils are located north, within, and south of the boundary of the former FWEC Facility property. The Cl series extends into the area occupied by the SIPs and is also present along the southern boundary of the Affected Area. The soils are present along slopes ranging from 0 to 8 percent grade.

The LB soils consist of well drained and moderately well drained soils on uplands, generally formed in glacial till. The LB soils are generally present at the eastern to central extent of the Affected Area, generally along Church Road. The soils range from a dark red-brown silty loam to a very stony or extremely stony silt loam layer at the surface, approximately eight inches thick. The soils are present along slopes ranging from 3 to 8 percent grade.

The M series soils consist of poorly drained soils present at uplands. The soils were formed in glacial till derived mainly from sandstone, siltstone, and shale. The M series of soils are common throughout the Site and are found along Church Road, east of the property boundary of the former FWEC Facility. These soils are also the predominant soil type identified along Watering Run and Church Road through the Affected Area. A silty or very to extremely stony loam layer is generally present at the surface, approximately four inches thick. The soils are present along slopes ranging from 0 to 15 percent grade.

The Ol and Op series soils consist of well drained to excessively drained soils present at upland areas. The soils generally formed in glacial till, derived from sandstone, siltstone, or shale. The parent material is generally identified from the amount of gravel present in the soils. A silty loam or very to extremely stony loam is present at the surface layer of the soils, approximately six inches thick. The soils are generally located along the steeper slopes present at and near the Site, along the Watering Run valley in the Affected Area and within Crestwood Industrial Park. The soils are present along slopes ranging from 3 to 25 percent grade.

The RB series soils consist of poorly drained soils located along terraces and glacial moraines. The soils formed in glacial outwash deposits derived mainly from sandstone and shale. The soils typically have a silt loam surface layer eight inches thick. The series is located within the Affected Area, south of Watering Run, and west of Stone Wall Circle. The soils are present along slopes ranging from 3 to 8 percent grade.

The Wl and WM soils consist of moderately well to somewhat poorly drained soils present along uplands. The soils formed in glacial till derived from sandstone, siltstone, and shale. This series of soils is located through the area of the Site, predominantly within Crestwood Industrial Park, the former FWEC Facility property, and the western portion of the Affected Area. The soils are present along slopes ranging from 3 to 25 percent grade.

3.4.3 Site-Specific Geology

The Site is located in an area where glacial deposits overlay folded and slightly metamorphosed sedimentary bedrock formations. Based on a review of the historic and recent geologic logs, site geology is comprised of two primary stratigraphic units – overburden and bedrock. The overburden consists of unconsolidated glacial till and minor occurrences of fill in the SIPs area. This till is underlain by two types of incompetent bedrock; weathered bedrock underlain by highly-fractured bedrock. Less fractured, competent bedrock underlies the incompetent bedrock. The presence and thickness of the till and the weathered bedrock varies across the Site.

The highly-fractured and less fractured, competent bedrock is mainly comprised of sandstone with interbedded siltstone and shale. The sandstone is primarily gray in color and the siltstone is primarily red or gray in color. These observations are consistent with the regional interpretation of a continental margin depositional environment described as red to gray shales and sandstones typical of the Duncannon Member of the Catskill Formation. The results of the downhole geophysical logging (Appendix H) indicated the typical dip of the geologic bedding is to the Southeast at an average dip angle of 20 degrees from horizontal. The average strike of the bedding planes is to the Northeast at an angle of 39 degrees from North. This correlates well with regional literature observations discussed above.

Site-specific borings located at and within the surrounding area of the former FWEC Facility from previous investigations indicate unconsolidated deposits are generally present to depths ranging from approximately 15 to 160 feet below ground surface (bgs) (WCC, 1986 and EPA-1D Boring Log). Rock cores collected at the Site during previous investigation activities indicate fractures were common within shallow bedrock at depths generally less than 100 feet bgs (WCC, 1987). The descriptions of the rock cores collected from the Site during the current investigation are similar to those provided above and generally indicate a pre-glacial weathered bedrock surface that can be penetrated using a split-spoon sampler (i.e., RMW-02S) to varying degrees and recovery. Rock coring below weathered bedrock indicates a zone of highly fractured rock, as shown in the boring log for EB-01, consisting of fine to medium grained brown to red sandstone with horizontal laminar bedding. In all of the bedrock borings, fractured rock transitions with varying depth to relatively low fractured competent bedrock with RQDs reported above 75 percent.

Geologic logs from select existing wells, as well as newly-installed wells, were reviewed to obtain the depth to bedrock. These data were used to construct a soil-bedrock interface elevation map. The bedrock iso-elevation contour map, Figure 3-6, shows a similar morphology to that of the ground surface presented in Figure 3-1. Figure 3-6 indicates the Site is located on the bedrock elevation high and the surface dips to the southwest and eventually to the west. The upper reach of Watering Run is located in a localized bedrock low in the top of the bedrock surface.

Site specific boring logs represented by RMW-02S located in the SIPs, and RMW-09S located in the Affected Area, indicate the unconsolidated, overburden deposits are mainly comprised of brown to red sands in a fine grained matrix of sand and silt, with varying minor components of clay and gravel, typical of a glacial till. Frequent presence of cobbles and boulders can be seen in these two logs by virtue of split-spoon refusals. There are no readily apparent trends to the distribution due to the heterogeneous nature of the material. However, there are several isolated locations where there is a noticeable change in grain size to a more sorted coarse sand as shown in boring logs RMW-11S and RMW-14S. These sandy areas are near the Wisconsinan Ice-Contact Stratified Drift area noted on Figure 3-3, which is based on regional surficial geology mapping.

3.5 Hydrogeology

3.5.1 Regional Hydrogeology

The bedrock Catskill Formation is the primary source of groundwater for the region near the Site due to its expansive areal extent and the low potential yield from the overburden glacial till. Drinking water wells installed in the area typically range in depth from 24 to 580 feet bgs and range in well yield from 2 to 325 gallons per minute (Newport, 1977). Recharge to the Catskill Formation is primarily through precipitation infiltrating through the glacial deposits. A hydraulic connection is likely present between the overburden till and bedrock at the former FWEC Facility, as there does not appear to be a confining layer separating the geologic units.

Hydrogeologic studies of sedimentary rock formations of similar type to the Catskill Formation indicate the primary direction of groundwater flow is parallel to the strike of the rock formation and within bedding plane partings present within the bedrock (Michalski, 1997). Water table elevation contour maps prepared during previous investigations are generally consistent with these findings and indicate the direction of groundwater flow at the former FWEC Facility is generally to the south-southwest. This south-southwest groundwater flow is along the strike orientation of the geologic units, other surface related drainage features, and horizontal and vertical flow pathways related to the structure of the bedrock.

In addition, groundwater elevation data indicate that groundwater in bedrock at depth may be under confined or semi-confined conditions in the eastern part of the Affected Area. Artesian conditions have been observed at seven monitoring well locations (Table 2-33) at the Site during the RI field investigation. Groundwater to surface water discharge points, such as groundwater seeps and springs, also are present at the Site and are typical for relatively steep topographic slopes overlain by till. Consistent with field investigations performed previously, the most permeable zone within the bedrock is estimated to be within the first 30 to 50 feet of bedrock, with decreasing permeability as the bedrock becomes increasingly competent with depth.

3.5.2 Site-Specific Hydrogeology

On December 13, 2012, a step drawdown test was performed to evaluate the hydraulic characteristics of the area in the vicinity of RMW-01D. The test was performed by pumping water from well RMW-01D and measuring water levels in response to the pumping. The test was performed in the open bedrock borehole at RMW-01D prior to FLUTe installation. The open borehole interval was from 138 to 325 feet in depth bgs. Two observation wells, RMW-02D, screened from 168 to 178 ft. bgs, and RMW-06D, an open borehole, located approximately 450 and 1,250 feet from the pumping well, respectively, were gauged to evaluate if pumping would affect water levels remotely. Data are summarized in Table 3-1.

The step drawdown test was performed by incrementally increasing the pumping rate at four intervals ranging from 2.3 to 9.9 gallons per minute (gpm). The test duration was 207 minutes, during which more than 1,500 gallons of water were pumped. The maximum drawdown achieved during the test at RMW-01D was 4.2 feet. Because the water level elevation data did not indicate stabilized conditions at each step, an average specific capacity was calculated. Based on a weighted average pumping rate of 7.29 gpm and the 4.2 feet of total drawdown, an average specific capacity of 1.74 gpm per foot of drawdown was calculated. The water level measurement data collected from well RMW-02D indicated hydraulic influence due to pumping RMW-01D. A steady decrease in water levels was observed during the test, with a maximum drawdown of 0.26 feet at RMW-02D. Water level measurement data collected from RMW-06D showed a decrease of 0.05 feet during pumping of RMW-01D. Based on this observation, there appears to also be a hydraulic connection between RMW-01D and RMW-06D, however, the influence could not be definitively quantified due to the distance between the wells and the small response observed.

Groundwater elevation contour maps were generated from the water elevation data collected during the three rounds of groundwater sampling conducted in May 2013, September 2013, and April 2014. For each round of sampling, the shallowest well at each location was selected to interpolate groundwater flow direction at the site. Well with screens or open holes significantly below the groundwater surface were not included in the analysis. The water table iso-elevation contour maps for each of these events, provided as Figures 3-7A through 3-7C, indicate groundwater flow directions similar in morphology to the ground surface and the top of bedrock surface. These data indicate groundwater flow direction on and near the FWEC property is generally to the south-southwest and, at more distal locations from the FWEC property, in the Affected Area, groundwater flow direction is generally to the west.

During the groundwater elevation measurement events, the on-site GETS was fully operational, and the effects of the groundwater treatment system extraction wells can be seen on each of the figures, with low points in the groundwater elevation evident in the vicinity of the extraction wells.

As shown on Figure 3-7A, a groundwater elevation high is consistently observed near well cluster RMW-03, located in the southeast corner of the CertainTeed facility, resulting in a localized occurrence of northwesterly groundwater flow which also influences the primary groundwater flow direction to the west down the valley. Groundwater flowing southwesterly from the former FWEC Facility through some of the SIPs is directed into a more westerly flow direction by the northwesterly flow gradient caused by the localized groundwater elevation high. The collected data also indicate that groundwater contamination originating in the area of the CertainTeed and Bergen Machine facilities might be migrating locally in a northerly direction onto the former FWEC Facility property as a function of groundwater gradients induced by the currently operating extraction wells.

An evaluation of the hydraulic head and gradients at the Site includes the analysis of the horizontal and vertical gradients, their direction and their relationship to plume morphology and physical conditions at the Site. Table 3-2 presents the vertical gradients for each well cluster for the three rounds of water elevation data. Vertical gradients at the Site were calculated by comparing the relative water elevations in the wells at each well cluster. When the variance shows a value greater than 0.10 feet, the gradient is considered downward, while a value less than -0.10 is considered upward. If the variance was calculated between -0.10 and 0.10 the gradient was considered neutral. The primary vertical gradient at the Site was generally downward or neutral. Two well clusters on the former FWEC Facility, CH-3/CH-3A and MW-12/MW-12D, showed a consistent downward trend. These wells, located at higher elevations on the former FWEC Facility, indicate the overburden (glacial till) is recharging the bedrock on the upgradient portion of the Site. Four well clusters, RMW-06, RMW-07, RMW-13, and RMW-14, showed mixed vertical gradients, with no apparent trend. Three well clusters, MW-14, FWEC-6 and RMW-09, showed variable patterns with depth. The variable patterns may be associated with recharge from precipitation events.

Horizontal gradients were calculated from the three rounds of groundwater elevation data. Five different areas of the Site were evaluated to assess groundwater gradients. Table 3-3 presents the horizontal gradients for several transects along the assessment area for the water table screened wells.

The distal portions of the Affected Area show horizontal gradients averaging approximately 0.034 feet vertical per foot horizontal, which is approximately one third that of the gradient calculated in the vicinity of RW-2R near the southern FWEC property boundary. The horizontal groundwater gradient for areas further upgradient on the former FWEC Facility are slightly lower than the distal portions of the plume at 0.025 ft/ft.

Although regional studies indicate that bedding plane orientation controls groundwater flow, site specific data indicates that the primary controlling factors dictating groundwater flow direction in the Affected Area are the overall shape of the valley, the presence of Watering Run (as a local groundwater discharge point), and the top of the bedrock surface. Rainfall variation appears to influence the groundwater flow direction on portions of the former FWEC Facility and has a less pronounced effect on off-property areas where the valley shape and bedrock configuration constrain groundwater flow more consistently. The presence of the perennial gaining stream (Watering Run) along the valley floor also helps to channel groundwater flow along the topographic contours of the valley. At a large scale, geologic structure (i.e., bedding and fracture planes) does not appear to have a significant controlling influence on groundwater flow. At a smaller scale, it appears that groundwater flow is locally affected by changes in hydraulic head and gradients, and geologic heterogeneity.

Flow within the till is likely to correspond to unconsolidated deposit heterogeneity, with some degree of preferential flow as a function of the differences in hydraulic conductivity that naturally exist as a function of this heterogeneity. Flow within the weathered bedrock is likely to be variably influenced by the local degree of weathering, wherein flow would be dominated by former fractures (secondary porosity) enhanced by weathering. Some degree of attenuation via diffusion into the weathered matrix (primary porosity) is also likely. Flow within the highly-fractured bedrock and less-fractured, competent bedrock is likely to be dominated by fracture flow, with probable higher transmissivity conditions existing in the more highly-fractured bedrock.

3.6 Ecological Setting

The following provides a summary of the ecological setting based on the results of the ecological reconnaissance performed at the Site. Additional details and photographs are included in the SLERA, provided as Appendix L.

3.6.1 Ecological Setting

3.6.1.1 Former FWEC Facility and Surrounding Industrial Properties

The former FWEC Facility is covered by large former building cement slabs, asphalt and gravel parking lots and access roads and open field areas formerly used as storage areas. A former WWTP also is present and covers an area of approximately 0.16 acres. While evidence of wildlife occurrence on the former FWEC Facility was observed, the lack of significant habitat present in the developed portion of the former FWEC Facility limits its value for supporting significant populations of ecological receptors. The former WWTP does afford limited habitat value as open water, though its small size and potential intermittent nature limit its ability to support a permanent aquatic community.

3.6.1.2 Affected Area

The Affected Area is approximately 295 acres of mixed land use centered along the main channel of Watering Run. This area consists of riparian, wetland and open water habitats of Watering Run. Tributaries and groundwater seeps and springs discharge along the channel course. The riparian and wetland habitats present include upland broadleaf deciduous forests, low land broadleaf deciduous forests, emergent wetland areas and ephemeral springs. The open water channel of Watering Run originates on the former FWEC Facility and flows downgradient, converging with multiple tributaries and ephemeral springs along the length of the Affected Area. The aquatic, riparian and terrestrial habitats present within the Affected Area represent the most significant habitats present at the Site.

3.6.1.3 Surrounding Industrial Properties

The SIPs also occur adjacent to the channel of Watering Run and downstream of the former FWEC Facility. The SIPs area consists of multiple industrial and commercial properties all with associated impervious asphalt parking areas, mowed lawn and landscaping features. These properties at the time of the ecological reconnaissance were active or under advertisement for lease with associated pedestrian and vehicular traffic associated with the individual operations. The developed nature of the SIPs do not afford significant value as wildlife habitat. The only exception are isolated, fragmented or adjacent forested areas present on the properties associated with the forested corridor of Watering Run. The isolated or marginal value of these areas are limited in providing high quality habitat individually, but may provide some value as buffer habitat being contiguous to the larger more continuous areas present in the Affected Area.

3.6.2 Terrestrial Vegetation Cover Types

Six vegetation cover types were identified at the former FWEC Facility and in the Affected Area:

- Deciduous, broad-leaved upland forest;
- Deciduous, broad-leaved lowland forest;
- Deciduous, broad-leaved scrub-shrub;
- Early successional fallow field;
- Emergent wetland; and
- Managed field or vacant land.

These cover types were grouped into three distinct vegetation strata:

- Primary Canopy composed of mature trees resulting in a semi or fully closed canopy by tree crowns;
- Secondary Canopy composed of tree samplings and mature shrubs or vines forming a substrata of woody vegetation beneath the primary canopy and above the soil surface; and,
- Groundcover composed of herbaceous weeds, forbs, wild flowers, moss or seedlings of woody vegetation, occurring at or just above the soil surface.

3.6.3 Aquatic Habitats

The former FWEC Facility includes the headwaters of two streams and a small, former WWTP. The two streams are:

- Watering Run, the larger stream that bisects the investigation area; and
- The outflow channel from the former WWTP that drains to an unnamed tributary to Bow Creek, a drainage feature flowing to the northeast and off the former FWEC Facility property.

Both streams are sub-drainages of the Big Wapwallopen Creek basin, a tributary of the Susquehanna River. The PADEP classifies both Watering Run and Bow Creek and their tributaries as supporting environmental characteristics for cool water fisheries and for migratory fish (PA Code Chapter 93: 93.9k). Prevailing groundwater flow from the Site is to the south-southwest, then west along the sub-basin of Watering Run. These aquatic habitats are discussed in further detail below.

3.6.3.1 Watering Run

Watering Run originates on the former FWEC Facility and flows in a southwesterly direction before turning west and continuing through the central portion of the Affected Area. The headwaters for this stream form at the topographic base of the former FWEC Facility footprint and the stream continues through the Affected Area to its confluence with Big Wapwallopen Creek. A detailed description of the environmental setting and character of the stream channel by linear segment reaches is provided in the SLERA, Appendix L.

3.6.3.2 Unnamed Tributaries to Watering Run

Within the Watering Run sub-basin of the Affected Area, several small unnamed tributaries that discharge to Watering Run were identified. These small tributaries appear to be intermittent in nature with flow being affected in large part by precipitation and shallow groundwater. Flows in these tributaries typically originate from diffuse discharges from forested wetland areas dominated by sensitive fern and skunk cabbage or from dendritic intermittent channels. Hydrologic regimes in each of the tributaries was not verified on a continuous basis, though low flow surface water sampling was able to be performed indicating that water flow is present during historic low flow periods of late summer to early fall (August to September). The channel width of these tributaries is narrow at 1 to 3 feet and water depth is shallow, typically less than 1 foot, indicating suitable physical aquatic habitat for lotic benthic invertebrate communities and amphibians. Given their small width, depth and potential for intermittency, these waters would support very limited fish communities. Water quality standards and/or criteria consistent with that of Watering Run apply to these tributaries.

3.6.3.3 Groundwater Seeps and Springs

During the Site reconnaissance and other investigation efforts, groundwater seeps and springs were identified along the Watering Run channel or on adjoining properties and tributaries to Watering Run. These features vary in physical setting and hydrology with some being representative of artesian flow and some being indicative of a passive, diffuse flow regime subject to intermittent discharges. In several cases, flow of these features has been piped and modified by property owners to control erosion and flooding. Others are indicative of a natural, ephemeral groundwater to surface water transition environment supporting aquatic and wetland communities at and below its origin. These areas are characterized by moss encrusted, partially embedded cobble beds with substrate diffused flow and pooled water areas present. Artesian conditions were identified by noticeable and concentrated flow within the cobble beds. One seep was located behind a commercial hardware store where flow was diverted via pipe to a manmade pond before discharging to Watering Run. Discharges from the seeps and springs are characterized by cooler water temperatures, slightly lower dissolved oxygen concentrations, slightly acidic pH, and coarser bottom substrates largely dominated by cobble and gravel. Additional information is provided in the SLERA, Appendix L.

3.6.3.4 WWTP

The WWTP is shallow, less than 2 feet in depth, and the majority of the pond is colonized by narrowleaf cattail and pondweed species. Inflow to the pond is limited to overland storm water runoff from the former FWEC Facility, shallow groundwater, and storm water runoff from impermeable areas of the former building footprint areas. The lack of any significant overhanging vegetation results in the pond basin being exposed to sunlight during the majority of the day, contributing to the elevated water temperatures present. The lack of fish in the pond also was noted due to the significant sedimentation build-up within the basin. Sediments of the pond were characterized as soft, unconsolidated silts and fine sands with significant accumulation of coarse and fine organic matter, largely newly fallen and decomposing leaves and senescent aquatic vegetation.

3.6.4 Fish and Wildlife Observations

Wildlife observations by project ecologists were made during the ecological reconnaissance in October 2011 and during subsequent field efforts for other tasks as part of the RI field investigation in 2012. These observations represent a qualitative inventory of species and do not represent a comprehensive quantitative inventory of all potential species present. Nearly all of the species encountered were associated with forested habitats common in the Affected Area and were more limited at vacant or formerly developed lands associated with the former FWEC Facility. With the exception of overhead bird observations, occurrence of terrestrial wildlife on the former FWEC Facility property were limited to scattered observations of tracks or occurrences along the ecotone of habitats previously described. Table 2 in the SLERA, Appendix L, identifies the wildlife species observed in the terrestrial, wetland and aquatic habitats at the Site. The greatest number of observed species was associated with the broad-leaved deciduous upland and lowland forests and riparian habitats of the Watering Run channel within the Affected Area.

The aquatic habitats observed included the former WWTP, the headwaters and main channel of Watering Run, and associated tributaries and groundwater seeps and springs discharging to Watering Run. The WWTP, the headwaters of Watering Run and the groundwater seeps and springs did not support fish due to their limited hydrology, shallow depth or intermittent nature. This lack of a fish community plays an important role in the use of these habitats by amphibians as refugia both for reproduction and as foraging habitat. The heavily shaded environments of the groundwater seeps and springs make these important habitats for woodland salamanders and tree frogs, which depend upon vernal pools and streams for refugia from predation and provide feeding and reproduction habitat.

The shallow apparent intermittent character of the channel on the former FWEC property limits it ability to sustain a permanent fish population. Observations of fish activity were limited to the lower channel of Watering Run below the Oak Hill Road conduit. Observations of fish were typically limited to pool areas where water depths exceeded 12 inches. While formal surveys were not conducted, field observations recorded during surveys indicated that the minnow family (Cyprinidae) appeared to be present. Smaller fish species from other families also may be present.

3.6.5 Threatened and Endangered Species and Communities of Special Concern

Requests for information regarding the presence of endangered and/or threatened species were submitted to the Pennsylvania Natural Heritage Program's online database for the identification of state listed endangered or threatened species, and to the USFWS for federally listed species. A response from the PA Natural Heritage Program identified the barrens buckmoth (*Hemileuca maia*), a moth species of special concern, as potentially occurring at the Site, as well as the potential occurrence of scrub oak shrublands, a habitat resource of special concern. However, this cover type was not observed at the former FWEC Facility or in the Affected Area.

Review of the Pennsylvania Natural Diversity Inventory database also revealed that two federally endangered species, the Indiana bat (*Myotis sodalist*) and the northeastern bulrush (*Scirpus ancistrochaetus*), potentially occur within the Upper Susquehanna River Basin in the vicinity of the Site. Their occurrence within the Site vicinity has not been confirmed. Correspondence with the USFWS identified the project site to be in close proximity to a known Indiana bat hibernaculum. Additionally, the former FWEC Facility and Affected Area also are located within the historical range of the northern long-eared bat (*Myotis septentrionalis*), a federally listed threatened species. No critical habitat for this species has been proposed or identified at this time.

4.0 NATURE AND EXTENT OF CONTAMINATION

This section describes data quality assessment and validation, as well as the on-site contaminant distribution and spatial and temporal trends identified during desktop, 2-D and 3DVA evaluation of the data obtained during the RI and from prior investigations at the Site. The horizontal and vertical extent of the contamination, as well as the magnitude present in Site media are discussed. The major findings presented in this section also are summarized in Section 6.0, Conceptual Site Model.

4.1 Data Quality Assessment and Validation

The RI included the sampling of multiple types of environmental media to delineate the nature and extent of potential contamination, as set forth in the USEPA-approved RI/FS Work Plan and as discussed in Section 2.0. The majority of the laboratory analyses were performed by TestAmerica Laboratories, Inc. (TestAmerica), Edison, New Jersey, a State of Pennsylvania certified laboratory (No. 68-00522). Additional analyses were conducted by TestAmerica, Tallahassee, Florida (formaldehyde); TestAmerica, Irvine, California (1,4-dioxane); Microbac Laboratories, Inc., Maryville, Tennessee (Dehalococcoides ethenogenes); TestAmerica, Pittsburgh, Pennsylvania (surface water and sediments); and TestAmerica, Burlington, Vermont and/or Vertical V-Northeast, Inc., Rahway, New Jersey (geotechnical constituents). Specialty analyses in support of the bedrock matrix evaluation were performed by Stone Environmental, Barre, Vermont (VOCs in water); and Golder Associates, Mississauga, Ontario (physical properties). The additional sampling conducted in April 2016 underwent analysis at Eurofins Lancaster Laboratories, Lancaster, Pennsylvania (TAL metals, cyanide and TOC) and Brooks Applied Labs, Bothell, Washington (chromium, hexavalent chromium, total solids, ORP, and pH).

Definitive analytical data provided by the off-site laboratories were validated by a USEPA-certified data validator utilizing the relevant sections of the USEPA Region 3 Data Validation Guidelines, applicable sections of the USEPA National Functional Guidelines for Organic and Inorganic Data Validation, and best professional judgment. Screening data were not validated, which data included packer samples and the analyses performed as part of the rock matrix diffusion investigation by Stone Environmental. The validation evaluated the following types of QC elements as applicable to the analytical fraction and sample matrix: sample conditions, holding times, calibration records, laboratory and field blanks, surrogate recovery, internal standard area recovery, laboratory control sample recovery and precision, matrix spike/matrix spike duplicate (MS/MSD) recovery and precision, and field duplicate precision. Non-conforming QC items were evaluated with respect to their implications for data reliability and usability, and qualifiers were added to the data results as appropriate based on the results of the validation. The validation assessments were summarized according to USEPA Region 3 Data Validation Guidelines.

An Electronic Data Deliverable (EDD) also was prepared. As discussed with USEPA Region 3, the EDD will be provided electronically in the USEPA Region 2 EDD format compatible with EQuIS Enterprise 5.0. Copies of the data packages, data validation reports, and EDD will be submitted under separate cover.

4.2 Data Usability Evaluation

Data usability was assessed based on the adequacy of the results to fulfill the requirements of the PQOs. In addition to the validation review which assessed the laboratory data, the evaluation checked field investigation procedures, field logbooks, and other documentation records to verify that the sampling procedures were performed following the approved protocols, are of sufficient quality to satisfy the PQOs, and can be relied upon for performing the risk assessments and the FS. The following summary discusses the usability of the validated analytical results from the RI. The assessment excluded the samples analyzed as part of the rock matrix diffusion investigation, as these results underwent an independent evaluation by Stone Environmental (see Appendix G).

A total of 1,863 soil, groundwater, surface water, and sediment samples (including QC samples such as duplicates and field blanks) were sent for off-site laboratory analyses and underwent data validation review. The off-site laboratory samples contained 40,627 separate constituent results.

4.2.1 Precision

Precision was determined through replicate measurements of the same or identical samples, such as laboratory duplicate, matrix spike duplicate, and field duplicate samples.

4.2.1.1 Laboratory Precision

Approximately 98.1 percent (or 39,870) of the off-site laboratory analytical results were associated with precision samples that were within their prescribed limits, reflecting good laboratory practices. Approximately 0.6 percent (or 256) of the off-site laboratory analytical results had laboratory precision samples slightly outside limits, and were qualified as estimated after validation. Approximately 1.2 percent (or 501) were determined to be unusable due to severe data bias. A majority of these “rejected” results were VOCs which had relative response factors (RRFs) outside prescribed values in their initial and continuing calibration standards.

4.2.1.2 Field Precision

Field duplicate analysis was performed during the RI at a rate of approximately five percent, one duplicate collected for every 20 samples. The precision of the field sampling effort was determined by the analysis of 51 field duplicate samples, which corresponds to 3,602 possible sample/duplicate data pairs, for the following media:

- soil gas – 5
- indoor air – 1
- VI groundwater – 4
- MIP direct push soil – 1
- surface soil – 4
- Hydropunch® groundwater – 4
- packer groundwater – 5
- surface water – 6
- pore water – 1
- sediment – 3
- groundwater sampling events – 17

Field duplicate criteria are not specified in the validation guidance documents for USEPA Region 3, and as such, project personnel exercised professional judgment in evaluation of field precision during the validation assessment. Acceptance criteria for duplicates were generally considered to be RPDs of less than 30 percent for aqueous and air samples and less than 50 percent for solid samples, when both values were greater than five times the reporting limit (RL). If either sample value was below five times the RL, the duplicate analyses were deemed acceptable if the difference between them was less than the RL for aqueous samples and less than two times the RL (2RL) for solid samples. For the chromium speciation investigation conducted in April 2016, field duplicate acceptance criteria were less than 20 percent for aqueous samples and less than 35 percent for solid samples. Concentrations associated with non-compliant field duplicate sets were considered estimated as part of the data validation review.

The RPD was not calculated for any set of sample/duplicate data pairs where:

- Concentrations were not detected in both of the data sets;
- Only one detection was present for either the original sample or the duplicate but not both;
- At least one of the samples was not analyzed (266 sample pairs); and
- A data result value was deemed unusable ("rejected") during validation for at least one of the samples (31 sample pairs).

Agreement between the original sample and the duplicate can be inferred when:

- Both of the results are non-detects, which occurred for 2,683 sample/duplicate data pairs;

- When the one detected result value is below the reporting limit of the other sample set (40 sample/duplicate data pairs); and
- If the one detected result value is greater than the RL but the difference is less than the RL or 2RL criteria stated above (35 sample/duplicate data pairs).

There were, however, 16 occurrences where the detected concentration was greater than the reporting limit for the other data set and the difference between the values was greater than the RL or 2RL criteria.

For the off-site laboratory duplicate analyses, 547 RPDs could be calculated. RPDs for these sample/duplicate data pairs ranged from 0 to 184 percent. Over 80.8 percent or 442 of the RPDs were less than their acceptance criteria and are considered acceptable, showing good agreement between the sample/duplicate data pairs. The remaining 105 or approximately 19.2 percent had calculated RPDs which exceeded acceptance criteria. A majority of these RPDs occurred for the vapor intrusion samples, which may be related to interferences in the efficient collection of soil gas sample replicates, possibly due to leakage, introduction of ambient air, etc. and the relatively low levels of constituents detected.

4.2.2 Accuracy

Accuracy of the data, or the degree of agreement between a measured result with the accepted true value, was determined in the laboratory through the use of surrogate compounds, internal standard compounds, matrix spike samples, and laboratory control spike samples. The majority of the off-site laboratory analytical runs, 39,801, or almost 98 percent, had percent recovery measurements within the prescribed method limits. A total of 819 separate constituents (or approximately 2.0 percent) were estimated following validation based on exceeding the appropriate recovery limits. There were seven concentration results (or approximately 0.02 percent) that were considered unusable due to gross recovery limit exceedances, and most of these values were due to very low spike recovery for silver in sediment samples.

Due to the difficulty in consistently analyzing for 1,4-dioxane as a result of its chemical properties (USEPA, 2006), a performance evaluation (PE) study was conducted along with the April 2014 groundwater sampling event. The assessment was designed to establish the laboratory's proficiency in preparing and analyzing samples and to determine if acceptable performance would be obtained using USEPA SW-846 Method 8260 with select ion monitoring (SIM), heated purge and trap, and isotope dilution. Two "ready-to-analyze" PE samples, with concentrations of 5.03 ug/L and 100 ug/L, were shipped daily to the laboratory in addition to the groundwater samples over the course of the four-day sampling event. Recovery of the spiked 1,4-dioxane ranged from 105 to 119 percent. These results are within the limits established for 1,4-dioxane in laboratory control samples, from 70 to 125 percent, indicating acceptability.

4.2.3 Representativeness

Representativeness of data occurs through the selection of appropriate sampling locations and the implementation of approved sampling procedures. Sampling locations were originally based on historic Site features, potential disposal practices, previous investigations, and other specific determinations. Field personnel followed the procedures outlined in the USEPA-approved RI/FS Work Plan and USEPA-approved FCRs during the investigation. Adherence to the approved procedures and protocols, in addition to collection of a sufficient number of samples from properly selected locations, increased the ability of the data to be representative of Site conditions.

To further assess procedural implementation, senior-level project personnel conducted field inspection audits for the project during the course of the field investigation, to verify that sampling was being correctly implemented according to the USEPA-approved RI/FS Work Plan. The audit findings indicated that the activities were in compliance with the RI/FS Work Plan, and no major issues were noted during the inspections. In addition, the RI is under USEPA Region 3 supervision, and performance of the majority of the field investigation program was overseen by a USEPA oversight contractor.

The validation evaluation also assessed sample conditions, such as blank contamination, appropriate sample preservation, adherence to holding times, percentage of moisture associated with a sample, and identification of constituents, as part of the determination of data representativeness. Approximately 97.7 percent (or 39,707) of the values were associated with results not requiring qualification during the evaluation for these conditions. Approximately 2.1 percent (or 853) of the results were qualified either as estimated for being marginally outside the QAPP prerequisites or potentially having a contribution from a blank sample. Data were deemed unusable due to non-representativeness for 0.16 percent (or 67) of the results. Most of these rejection qualifications are associated with inconsistencies observed in the 1,4-dioxane results from FLUTe monitoring wells during the May 2013 and September 2013 groundwater sampling events, potentially the result of sampling methodologies (Sections 2.11.6 and 2.11.7). In addition, due to elevated pH outside the methodology parameters, the results of the chromium/hexavalent chromium analyses for the April 2016 groundwater round were deemed unusable.

4.2.4 Comparability

To increase the degree of comparability between data results and between past, present and future sampling events, standard environmental analytical methods were employed by the off-site laboratories. These methods were the accepted analytical methodologies specified in the USEPA-approved RI/FS Work Plan. As necessary, modifications were requested by the laboratory and approved by the project team prior to analysis, and these variations were typically enacted to improve laboratory performance, such as analysis for 1,4-dioxane using the SIM/heated purge and trap/isotope dilution technique. Deviations from the analytical method and/or QAPP requirements occurred for a very small amount of the data set as discussed previously for the precision, accuracy and representative characteristics in Sections 4.2.1, 4.2.2 and 4.2.3, respectively.

4.2.5 Completeness

Completeness is determined by the percentage of samples that meet or exceed the criteria objective levels, such as the number of usable sample results for the data set. The objective for completeness for the overall field investigation was 95 percent. Approximately 1.4 percent of the data or 575 constituent results were considered unusable. Therefore, a total of 40,052 constituent results or approximately 98.6 percent was determined to be usable results, which surpasses the 95 percent objective for completeness for the RI.

4.2.6 Sensitivity

An evaluation of reporting limits was part of the determination of analytical methods during the planning phases of the project to verify that the sensitivity of the chosen methods was adequate to meet the applicable screening criteria. The original analytical methods were selected based on, depending on the analytical fraction, either all or a majority of the constituent reporting limits being less than possible comparison criteria values, with special attention paid to the contaminants of potential concern at the Site. In accordance with standard laboratory practices, RLs were adjusted from those outlined in the QAPP as a result of reduced sample volume, percent moisture/percent solids, and dilution requirements due to elevated concentrations and/or matrix effects. The adjusted RLs were reflected in the laboratory-provided data, and are provided as applicable on the individual summary tables discussed in this section. The data evaluation and resulting conclusions were not affected by adjustment of the RLs.

4.2.7 Summary of Usability

The data for the RI fulfilled the project-specific objective requirements, with only minor exceptions, with about 1.4 percent of the results not able to be used. Therefore, the Site database is considered acceptable for use to support Site decisions.

4.3 Selection of Screening Criteria

Multiple screening criteria exist for use during interpretation of the nature and extent of contamination at the Site. These values are not, however, the definitive basis for determining chemicals of potential concern for either the human health or ecological risk assessments. Both Applicable or Relevant and Appropriate Requirements (ARARs), i.e., standards promulgated under federal or state law, and "To Be Considered" (TBC) guidance values, i.e., levels provided by regulatory agencies but not promulgated, were obtained, and these screening criteria include

USEPA human health-based values, USEPA ecological-based values, and PADEP values, along with other values as applicable.

The following subsections discuss the available screening criteria, and Tables 4-1A through 4-1H provide a summary of all of the obtained values. For select ARARs/TBCs, the criteria originally provided in the RI/FS Work Plan have been updated, and these tables include the most current values at the time of this report. In general, discussion within this section on the nature and extent of contamination applies a subset of these screening values chosen to be applicable to the environmental medium and potential exposure pathways of interest, and the selection of the specific comparison criteria utilized is also discussed below.

4.3.1 Vapor Intrusion Evaluation

4.3.1.1 Soil Vapor

The soil vapor data were compared to target sub-slab and exterior soil gas concentrations calculated with the USEPA Vapor Intrusion Screening Level (VISL) Calculator (Version 3.4). The calculator utilized the following parameters: residential exposure scenario, target risk for carcinogens [TR] of 1E-06) and a target hazard quotient for non-carcinogens [THQ] of 0.1. These screening criteria are provided in Table 4-1A.

4.3.1.2 Indoor Air

The indoor air screening criteria were also obtained from the VISL Calculator, for residential exposure with a TR of 1E-06 and a THQ of 0.1. The target indoor air concentrations are provided in Table 4-1B.

4.3.1.3 Groundwater

In addition, target groundwater concentrations for the groundwater to indoor air pathway were calculated for residential exposure with a TR of 1E-06 and a THQ of 0.1 using the VISL Calculator. These values are provided in Table 4-1C.

4.3.2 Soils

Soil screening criteria are provided in Table 4-1D for surface soils and Table 4-1E for subsurface soils. The screening criteria include the following:

- June 2015 USEPA residential and industrial RSLs for carcinogenic (with a TR of 1E-06) and non-carcinogenic (with a THQ of 1.0) risks (USEPA, 2015);

- Region III BTAG 1995 Soil Screening Levels (SSLs) (USEPA-R3, 1994; 1995) for surface soils only;
- USEPA Ecological SSLs (USEPA, 2010) for surface soils only;
- PADEP Medium Specific Concentrations (MSCs) (PADEP, 2011); and
- Default values for volatilization to indoor air, generated using USEPA Johnson and Ettinger Version 2.3 (March 2001), with PA Default Values defined in Table 8 of PADEP's Land Recycling Program Technical Guidance Manual - Section IV.A.4, Vapor Intrusion Into Buildings from Groundwater and Soil under the Act 2 Statewide Health Standard (PADEP, 2004b).

The soil samples collected as part of the RI were obtained from the former FWEC Facility. Current use of the property is industrial, and no change to usage in the future is projected. Therefore, the most stringent of the USEPA industrial RSLs was used during nature and extent screening, and these values are also shown on Tables 4-1D and 4-1E.

4.3.3 Groundwater

Screening criteria for groundwater data, other than results as part of the vapor intrusion evaluation, are provided in Table 4-1F. The screening criteria include:

- USEPA Drinking Water Maximum Contaminant Levels (MCLs) (USEPA, 2009c);
- June 2015 USEPA RSLs for Tap Water (USEPA, 2015);
- PADEP MCLs (PADEP, 2006); and
- PADEP MSCs (PADEP, 2011).

The most stringent of the USEPA RSLs, along with the USEPA MCLs, was utilized for the comparison screening of groundwater samples.

4.3.4 Surface Water and Pore Water

Surface water and pore water screening criteria are provided in Table 4-1G and include:

- USEPA Region III BTAG Freshwater Screening Benchmarks (USEPA-R3, 2006);
- USEPA Water Quality Criteria (USEPA, 2014b);
- June 2015 USEPA RSLs for Tap Water multiplied by a factor of 10 (USEPA, 2015);
- PADEP Water Quality Criteria for Toxic Substances, Chapter 93.8c, Table 5 (PADEP, 2009), and

- Preliminary Remediation Goals (PRGs) for Ecological Endpoints (Efroymson et al., 1997).

For the surface water results, the most stringent of the USEPA values are also shown on Table 4-1F, and will be used for comparison screening purposes.

4.3.5 Sediments

Table 4-1H presents the possible screening criteria for sediments, including:

- USEPA Region III BTAG Freshwater Sediment Screening Benchmarks (USEPA-R3, 2006); and
- PRGs for Ecological Endpoints (Efroymson et al., 1997).

The USEPA Region III benchmarks will be utilized during comparison to the analytical results for this RI.

4.4 Vapor Intrusion Investigation Results for the Affected Area

For the VI investigation, sampling was conducted for soil gas (63 samples plus 4 duplicates), ambient air (8 samples), indoor air (16 samples plus 1 duplicate), and groundwater (51 samples plus 4 duplicates) at properties within the Affected Area[4]. Section 2.3 provides the details for the sampling program. Tables 4-2A through 4-2D, respectively, provide summaries of the detected constituents for each of the matrices. Table 4-2E provides the list of the addresses sampled, and Table 4-2F identifies why specific locations were removed from further consideration.

During performance of the BHHRA, a comprehensive evaluation of the VI data for the Affected Area was performed and is provided as Attachment D to the BHHRA (which is Appendix M to this RI Report). As noted in this evaluation, the detected constituents in the Site plume were assessed in relation to their potential to create VI concerns. A majority of the volatile constituents detected in or in association with the various structures in the Affected Area were determined to be unrelated to or not of a health concern with respect to VI. The results of this evaluation are consistent with the initial findings following the VI investigation. TCE at two locations was identified as a potential concern in terms of possible VI constituting an indoor air inhalation exposure pathway of concern. Mitigation activities were performed at both of these locations in July 2011 to eliminate that concern.

[4] The USEPA-approved RI/FS Work Plan did not require sampling for VI or a targeted VI investigation for the former FWEC Facility or the SIPs.

4.5 Surface Soil Results

Surficial soils were sampled in two on-site areas, the former shot blast sands storage area (five samples) and the expended waste area (four samples plus one duplicate), to characterize the presence or absence of contamination. The location of these samples is shown in Figure 2-2A, and a summary of the detected constituents is presented in Table 4-3A. Tables 4-3B and 4-3C provide the results of the chromium/hexavalent chromium speciation and the background investigations, respectively.

Four constituents were detected at concentrations above USEPA industrial RSLs, including benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, and chromium. Benzo(a)pyrene and dibenz(a,h)anthracene are two PAHs that had detections greater than the screening criteria, but their relatively low-level presence in former shot blast sands storage area locations 04 and 05, and expended waste area location 08 may be associated with the railroad lines historically on the Site and/or former concrete slabs/footings.

Arsenic detections were greater than the screening criteria in all of the samples. The arsenic concentrations were relatively consistent in magnitude in both of these sampled areas, including at locations 04, 05, and 08 that had showed elevated PAHs. In addition, the concentration magnitudes were also similar in the soil samples collected from the two MIP areas (discussed below in Section 4.6), including at locations that contained elevated VOCs. Therefore, the arsenic detected does not appear to correlate to source areas at the former FWEC Facility.

Chromium concentrations were above the screening criterion for Cr[IV] in the 2011 former shot blast sands storage area and expended waste area soil samples. The detections were orders of magnitude less than the Cr[III] value. The additional surface soil samples collected in 2016 (Table 4-3B) indicate the majority of the chromium is Cr[III], with only minimal concentrations of Cr[IV], none of which were greater than screening criteria. In addition, the distribution of chromium concentrations are "not statistically significantly different" than background (see Attachment H of Appendix M for detailed statistical comparison).

4.6 Direct Sensing Tool Results at Former FWEC Facility Areas

As discussed in Section 2.5, the MIP direct sensing technology was utilized at the former vapor degreaser area (designated MIP Area #1) and around the Finish Paint Building, Solvent Building, and Paint Storage Building (designated MIP Area #2). During MIP tooling advancement, the ECD, FID, and PID instruments qualitatively characterized the occurrence of VOCs in the subsurface. The relative responses of the three detectors were assessed, and the general chemical composition in the environmental media (soil, water, and pore space) was obtained. In addition, confirmatory soil and groundwater samples were collected at select MIP sample locations.

Appendix N contains the MIP detector chromatograms. The MIP results are summarized by area in the following subsections.

4.6.1 Former Vapor Degreaser Area

Twenty-two MIP profiles were collected at and near the former vapor degreaser during the direct sensing field investigation, with four confirmatory samples collected from locations B2 (9.5 to 10 feet bgs); B4 (16.5 to 17 feet bgs); B7 (6.5 to 7 feet bgs); and B14 (18 to 18.5 feet bgs). Analytical results for these samples are summarized in Table 4-4. The maximum relative response of the chlorinated-related ECD column for each MIP Area #1 profile is shown on Figure 4-1, along with the VOC concentrations of the corresponding samples. The data indicate detected chlorinated constituents in the northern portion of the original former vapor degreaser/MIP Area #1 grid, with an area of highest subsurface impacts of approximately 0.08 acres in size. Corresponding analytical samples from two profiles within this area contained TCE detections greater than the USEPA industrial RSL (Table 4-4).

4.6.2 Former Finish Paint Building and Solvent & Paint Storage Building Area

Thirty-two soil profiles were collected in MIP Area #2, and the results are plotted on Figure 4-2 for the maximum relative ECD responses and in Tables 4-5A and 4-5B for the four soil and two groundwater confirmatory samples, respectively. The data indicate a detected mixture of chlorinated and non-chlorinated VOCs in the northern portion of the investigated area, with the most elevated detection in the soil and water analytical samples collected from location B20A. The area of the highest subsurface impacts is approximately 0.16 acres in size.

4.7 Groundwater Screening Evaluation Results at Surrounding Industrial Properties

Groundwater screening was conducted within the SIPs using a combination of Hydropunch® and sonic drilling techniques. The overburden groundwater was sampled at 14 locations, and the detected constituents are summarized in Table 4-6. Results for TCE are also provided on Figure 4-3. Five VOCs were detected at concentrations greater than screening criteria, and these occurrences appear to originate within three SIP locations, as follows:

- Detections of benzene, TCE, and vinyl chloride greater than screening criteria were present in groundwater from locations HP01 and HP11, which are located roughly in the central portion of the industrial park along Oak Hill Road between CertainTeed Corporation and Bergen Machine. Lower concentrations, although still above screening criteria in select intervals, were observed for benzene and TCE in HP03, HP04, and HP17. Vinyl chloride was not detected in the groundwater sampled from HP03, HP04, and HP17;

- Detections of bromodichloromethane and chloroform greater than screening criteria were present in groundwater from locations HP07, HP08, and HP09, which are located in the northern (HP07) and western (HP08 and HP09) portions of the industrial park near Quaker Oats/Gatorade, Fabri-Kal, and 755 Oak Hill Road; and
- Detections of chloroform greater than screening criteria were present in groundwater from locations HP13 and HP17, which are located in the southeastern portion of the industrial park near CertainTeed Corporation.

As shown in Table 4-6, formaldehyde was also detected during the groundwater screening investigation at concentrations above screening criteria in all sampled locations except HP08, HP09, and HP17.

4.8 Packer Groundwater Results for Well Installation

Tables 4-7A through 4-7R contain the summaries of the detected constituents from the packer assembly groundwater sampling for 18 bedrock wells. These screening-level results were utilized to determine the most appropriate screen interval(s) prior to installation of the monitoring wells. In general, a trend of decreasing concentration with depth was observed (see Table 4-7F for the example of RMW-01D). Exceptions to this tendency included RMW-06D and RMW-09D, which showed fluctuations in concentration across the sampled intervals, and RMW-07D, which contained a similar magnitude of TCE detections across a majority of the sample depths.

4.9 Surface Water, Sediment, and Pore Water Results

As outlined in Section 2.8, surface water, sediment, and/or pore water samples were collected at up to 30 locations in the former FWEC Facility, SIPs, and/or the Affected Area. Two events, designated as "high flow" and "low flow", based on the recent precipitation conditions, were conducted for surface water, with corresponding sediment samples collected during the low flow investigation. Pore water was obtained using PDBS at 12 of the locations. In addition, based on the initial eco-screening evaluation, supplemental sampling was conducted downgradient of the former WWTP (see FCR-12 in Appendix C). Location SD02 was also re-sampled in April 2016 for TOC. Summary tables of the detected constituents are provided as Tables 4-8A through 4-8F.

4.9.1 Surface Water/Pore Water Results

Up to 11 VOCs were detected in the surface water samples collected during the high flow and low flow events, with the concentrations less than screening criteria for all constituents except TCE and formaldehyde. TCE was generally found above its most stringent USEPA surface water criterion in the eastern to central portion of the Affected Area (Figure 4-4). Specifically, samples from seep locations SW-17 and SW-23, which are both groundwater-to-surface water discharge points, contained TCE detections during the two events, ranging from 29 to 31 ug/L at SW-17 and from 45 to 52 ug/L at SW-23. Formaldehyde was detected at a concentration greater than screening criteria (9.3 J ug/L) at SW-11, which is located within the tributary to Watering Run. Nominal differences were noted between the high flow and low flow events for the VOCs.

The pore water results were similar to the surface water data. Nine VOCs were detected, with TCE, carbon tetrachloride (PW-17 only) and vinyl chloride (PW-15 only) above the screening criteria (Table 4-8C). The samples from seep locations PW-17 and PW-23 contained detections of TCE at 35 ug/L and 40 ug/L, respectively, which are comparable to the surface water values. The nearest groundwater wells to the PW-17 location are RMW-08S/08D and RMW-09S/09D, where TCE detections in the groundwater ranged from 2.2 to 110 ug/L. PW-23, which had TCE detections of 48 to 61 ug/L, is located near the surface water spring samples.

Samples from the on-site WWTP (SW-01 through SW-04) had detections of SVOCs, pesticides (high flow event only), metals, and cyanide (high flow event only), with a portion of the detections above the screening criteria (Tables 4-8A and 4-8B). As noted above, supplemental sampling was performed to evaluate potential downgradient impacts in the outflow channel of the WWTP. However, as no surface water discharge was present at the outflow from the pond and minimal flow was present in the roadside ditch at the time of the supplemental event, surface water samples downgradient of the former on-site WWTP were unable to be collected.

During the low flow event, select surface water locations in the SIPs and the Affected Area also were sampled for metals. Aluminum, barium, chromium (compared to the hexavalent chromium screening criterion), iron, lead, manganese, sodium, and thallium were detected above the screening criteria. Based on the distribution of the detections and a comparison between total and dissolved concentrations, as well as the chromium speciation analysis (Table 4-8F), a majority of the aluminum, barium, chromium, iron, manganese, and sodium detected concentrations, and to a lesser extent the lead and thallium detected concentrations, appear to be related to the natural conditions of Watering Run. As shown in Table 4-8A, anthracene was detected above the most stringent USEPA surface water criteria in the northwestern portion of the Affected Area during the high flow event (SW-27 and SW-28). Based on the location of SW-27 and SW-28 and the lack of other detected constituents of concern in these samples, anthracene at this locality is not likely to be related to the Site.

4.9.2 Sediment Results

Four VOCs, acetone, chloroform, methylene chloride, and TCE, were sporadically detected at relatively low concentrations, less than 0.04 mg/kg, in sediment samples collected from a tributary to Watering Run and a seep during the low-flow sampling event. Formaldehyde also was detected in all of the sediment samples during this sampling event. There were no detections of these compounds above screening criteria (Table 4-8D).

The low-flow sediment samples (Table 4-8D) associated with the on-site WWTP contained SVOCs (mainly PAHs), pesticides, PCBs, metals, and cyanide. Many of the detected constituents were greater than the most stringent sediment screening criteria. Supplemental sediment samples (Table 4-8E) from the outflow channel from the WWTP (below SD-04) and the roadside ditch revealed limited detections of PAH compounds and metals. Based on the supplemental sampling, no significant migration of Site related constituents appears to have occurred from the WWTP.

Sediment samples collected from Watering Run, its tributaries, and the various seeps contained lower concentrations of SVOCs. Anthracene was detected slightly above screening criteria in SD-05 and SD-13 (0.087 and 0.065 J mg/kg, respectively) (Table 4-8D). Nine metals, consisting of arsenic, cadmium, cobalt, copper, iron, lead, manganese, nickel, and zine, were detected greater than the sediment screening criteria in six samples from Watering Run (SD-06, SD-09, SD-16, SD-19, SD-27, and SD-29). Based on the distribution of the detections and the lack of other detected constituents of concern in these samples, the metal detections are likely indicative of native conditions.

4.10 Groundwater Results

Multiple sampling events, with a total of 287 samples (plus 19 duplicates), were performed during the RI, and the results are provided, by event, in Tables 4-9A through 4-9N. For each event, the tables provide results for each constituent detected in one or more samples (with the exception of the chromium speciation event in April 2016 in Table 4-9N, which shows the analytical results for chromium (total), chromium (dissolved), and hexavalent chromium, regardless of occurrence or non-detect). The results for TCE, the primary constituent of concern and most frequently detected constituent associated with the former FWEC Facility, are summarized on Figures 4-5A and 4-5B, which present TCE sampling results by location and date, to show concentration distribution throughout the Site.

A total of 31 VOCs, including 1,4-dioxane and formaldehyde, were detected in at least one well during at least one of the sampling events, with a majority of these detections at low concentrations of less than 5 ug/L. A majority of these constituents were historically detected in groundwater on the former FWEC Facility. Based on the available data, constituents that did not originate from the former FWEC Facility include 1,2-dichlorobenzene; 1,4-dichlorobenzene; 2-chloroethyl vinyl ether; acrolein; and formaldehyde. Although vinyl chloride and 1,2-dichloroethane (1,2-DCA) were not historically present in the facility groundwater, these VOCs may be associated with the reductive dechlorination of TCE and 1,1,2-TCA, respectively. Vinyl chloride was sporadically detected during the more recent sampling events in the groundwater at the former FWEC Facility, the SIPs and Affected Area. 1,4-Dioxane was not analyzed in the historic events. Its presence is likely related to its use as a stabilizer in chlorinated solvents, primarily 1,1,1-TCA, which is a former FWEC Facility source constituent.

Regarding the detections, 15 constituents consisting of 1,1,1-trichloroethane (TCA), 1,1,2-TCA, 1,1-DCA, 1,2-DCA, 1,1-dichloroethene (DCE), acrolein, benzene, bromodichloromethane, carbon tetrachloride, chloroform, tetrachloroethene (PCE), TCE, vinyl chloride, 1,4-dioxane, and formaldehyde were present at concentrations greater than screening criteria.

Within the former FWEC Facility, TCE detections ranged in concentration from 0.11 J to 4,900 ug/L. The maximum concentration shows a significant reduction from previous sampling events at the former FWEC Facility, which had TCE values up to 180,000 ug/L. Overburden monitoring wells MW-2 and MW-4, and bedrock well MD-01 contained the highest detections of TCE (Figure 4-5A) on the former FWEC Facility. These wells are located in the central portion of the former operations area, with MW-4 and MD-01 located near the former vapor degreaser where the MIP investigation indicated the high ECD responses. To the east, TCE, 1,1,1-TCA, and dechlorination daughter products such as 1,1-DCA, 1,1-DCE, and cis-1,2-DCE, were detected in well cluster MW-7/MW-7S, along with a detection of 1,4-dioxane. 1,4-Dioxane was used primarily as a stabilizer in chlorinated solvents, particularly 1,1,1-TCA. The areas of elevated detections appear to be confined to this general area, since surrounding monitoring wells had significantly lower or no detections of these constituents.

Eight new wells were installed in the vicinity of the SIPs during the RI to supplement the existing wells from prior investigation activities. As shown in Figure 4-5A, TCE detections in this area ranged from 0.13 J to 310 ug/L. The higher TCE detections are contained in the lower overburden (RMW-01S-2, RMW-02S-2) and upper bedrock (EPA-2DR, RMW-01D-1, RMW-06D) zones, along the prevailing groundwater flow path downgradient from the former FWEC Facility. Data for shallow overburden well RMW-01S-1, located on the CertainTeed facility, indicated more elevated detections for 1,1,1-TCA, 1,1-DCA, 1,1-DCE, vinyl chloride, and/or 1,4-dioxane during the various sampling rounds than nearby wells at similar depth intervals, with non-detect results to low detections of TCE. For example, during the September 2013 round, concentrations of 1,1,1-TCA; 1,1-DCA; 1,1-DCE; and vinyl chloride ranged from 4 to 41 ug/L in RMW-01S-1, while monitoring wells MW-18 and RMW-02S-1 contained these constituents at non-detect levels to 7.6 ug/L (see Table 4-9J). In comparison, TCE was not detected in RMW-01S-1, while detections of 84 ug/L and 17 ug/L were present in in MW-18 and RMW-02S-1, respectively.

These chlorinated solvent-related constituents were historically detected on the former FWEC Facility or are daughter products of such compounds. However, the elevated concentrations of these constituents, in conjunction with the low observed concentrations of TCE and groundwater elevations, suggest an additional localized source, unrelated to the former FWEC Facility plume, contributing to the groundwater quality at this location. Hydropunch® groundwater screening results indicate localized detections of TCE in four of 14 sampling locations (GWP-HP-01, GWP-

HP-04, GWP-HP-11, GWP-HP-17) on and adjacent to the CertainTeed and Bergen Machine facilities. In addition, spatial data evaluation of the concentrations of TCE in those same Hydropunch® screening samples (GWP-HP-01, GWP-HP-04, GWP-HP-11, GWP-HP-17) and the monitoring well cluster downgradient of the Fabri-Kal facility (RMW-08S/RMW-08D) is further indication of additional localized sources.

In the Affected Area, TCE detections ranged from 0.12 J to 110 ug/L. These values are consistent to lower than historic data for residential wells in this area. The higher detections for TCE are contained in the lower overburden (RMW-09S) and upper bedrock (RMW-09D) along the north side of Church Road in the eastern portion of the Affected Area (Tables 4-9I, 4-9J, 4-9L, and 4-9M and Figure 4-5B).

During the December 2011 (interim) and May 2013 (Round 1) sampling events (Tables 4-9B and 4-9I, respectively), select monitoring wells were also analyzed for SVOCs, metals, and/or water quality parameters. Three SVOCs, bis(2-ethylhexyl) phthalate (BEHP), 1,2,4-trichlorobenzene, and hexachloroethane, were sporadically detected, with only one detection of BEHP above the screening criteria in RMW-04S-2 during the December 2011 sampling. The groundwater results for metals and cyanide do not correspond with known or suspected sources on the former FWEC Facility.

During the May 2013 (Round 1) sampling event, select wells were sampled for Dehalococcoides, to support a future monitored natural attenuation (MNA) evaluation. The results of these samples are provided in Table 4-9I.

4.11 Matrix Diffusion Investigation

The discrete fracture network (DFN) sampling from boring MD-01, located in the vicinity of the former vapor degreaser, included the collection of soil cores, description of the rock matrix, identification of fractures, and collection of samples for analytical and geotechnical analyses. A detailed description of the effort is provided in the data report from Stone Environmental in Appendix G.

A total of 44 samples, not including QC samples, were collected from the fractures and rock matrix of the Duncannon Member of the Catskill Formation at MD-01 and analyzed for TCE. Of the 44 samples analyzed, 17 were not detected above the method detection limit (sample-specific range of method detection limits was 0.7 to 2.0 ug/kg of rock). Of the 27 detections, 22 of the samples were above 5 ug/kg in the rock core. Overall, the trend of the data indicates that the concentrations generally decrease with depth, with detected concentrations below 5 ug/kg at depths greater than approximately 69 feet below ground surface. Samples collected at greater than 73 feet contained no detections of TCE above the method detection limits. Figure 4-6A illustrates the TCE detected concentrations with depth. The screened interval of well MD-01 and the fractures identified during drilling also are included in Figure 4-6A. The screen interval is closely coincident with the higher concentration values identified during the bedrock matrix sampling.

The bulk rock VOC concentrations were converted to matrix pore water concentrations utilizing physical properties of the core. As shown in Figure 4-6B, estimated TCE concentrations in the pore water ranged from 9.3 J ug/L at approximately 72 feet bgs, to 4,400 ug/L at approximately 44 feet bgs. The detected concentrations of TCE in the upper fracture and matrix samples, generally between 43 and 62 feet bgs, were generally within the range of concentrations found for the groundwater samples collected from MD-01 during Rounds 1 and 2 of the groundwater sampling events, where TCE was detected at 1,300 and 4,900 ug/L, respectively.

4.12 Summary of Nature and Extent of Contamination

4.12.1 Former FWEC Facility

Results from the RI confirmed the presence of on-site source areas in the vicinity of the former vapor degreaser and the Finish Paint, Solvent, and Paint Storage Buildings. The data obtained from the MIP survey indicate contaminant source areas of limited size, approximately 0.08 and 0.16 acres. The former shot blast sands storage area and expended waste area do not appear to be major sources for surface soil contamination, while sediment samples from the on-site WWTP showed non-VOC constituents above screening criteria.

The more elevated levels of TCE on the former FWEC Facility are located in the central and eastern portions of the former operations area, with 1,1,1-TCA and other chlorinated volatiles also present in the monitoring wells to the east. Surrounding monitoring wells showed significantly lower or no detections of these constituents during the RI. In addition, TCE concentrations in the groundwater in these areas have decreased approximately two orders of magnitude from historic levels.

The following summarizes impacted media and the associated contaminants for the former FWEC Facility:

- Surface soil – PAHs and arsenic
- Subsurface soil – TCE and arsenic
- Groundwater – VOCs, SVOCs and metals
- WWTP surface water – PAHs, pesticides, metals and cyanide
- WWTP sediment – SVOCs, pesticides, PCBs, metals and cyanide

4.12.2 Surrounding Industrial Properties

Data from locations in the central portion of the SIPs (on a northeast-southwest trend line), which is the prevalent groundwater flow path, indicate plume-related concentrations of TCE. In the eastern portion of the SIPs, near the CertainTeed facility, upper overburden groundwater contained little to no TCE, but did contain other constituents such as chloroform, 1,1-DCA, vinyl chloride, 1,4-dioxane, and formaldehyde. The lower overburden and upper bedrock groundwater in the eastern portion of the SIPs contained higher concentrations of TCE. In the western portion of the SIPs, little to no TCE was detected, although there were minor amounts of chloroform, benzene, and/or bromodichloromethane present above screening criteria in at least one groundwater sampling event. A noted exception is TCE detected in groundwater immediately southwest of the Fabri-Kal building.

Spatial data evaluation also indicates potential TCE contaminant sources in the vicinity of the CertainTeed, Bergen Machine, and Fabri-Kal facilities. TCE from these potential sources would migrate into the Affected Area. The collected data also indicate that groundwater contamination identified south of the former FWEC Facility, on portions of the CertainTeed and Bergen Machine facilities, might be migrating locally in a northerly direction onto the former FWEC Facility property, apparently as a result of local groundwater gradients being reversed by the recovery wells associated with the GETS at the former FWEC Facility. Any such migration of contamination onto the former FWEC Facility is being treated by the GETS already in place.

4.12.3 Affected Area

The groundwater plume has remained relatively consistent in size as compared to previous events, with consistent to lower TCE concentrations. During the RI, the more elevated concentrations of TCE were present in the groundwater in the eastern portion of the Affected Area. There were two seeps, one in the western portion and one in the central portion of the Affected Area, that also show elevated TCE concentrations as a result of groundwater-to-surface water discharge. TCE concentrations at the seep in the western portion of the site have remained relatively stable, while TCE concentrations at the seep in the central portion of the Affected Area have declined.

Vapor intrusion evaluation indicated potential concern in relation to the TCE groundwater plume at two properties in the Affected Area, and these locations underwent mitigation activities.

5.0 CONTAMINANT FATE AND TRANSPORT

An understanding of the environmental fate and potential transport mechanisms of the detected contaminants is necessary to determine the potential for continued migration, and to assess the potential for exposures to the contaminants for the FWEC/Church Road TCE Site. Two major characteristics affecting the fate and transport of a chemical are the mobility and the persistence of the chemical in environmental media. The major findings presented in this section also are summarized in Section 6.0, Conceptual Site Model.

Mobility is the tendency of a chemical to migrate through the environment. Mobility is controlled by both the physicochemical environment at a site and the behavioral characteristics of individual chemicals. Important factors controlling the physicochemical environment of a site include the local climate, the configuration and nature of surface water bodies and groundwater, and the nature of underlying soils and bedrock. Factors that control the behavior of individual compounds include aqueous solubility, the susceptibility of a chemical to sorption, and volatility.

Persistence is the tendency of a chemical to remain in the environment. Persistence is influenced by many of the factors affecting chemical mobility, such as solubility, sorption, and volatility, but also is a function of oxidation rates, hydrolytic and photolytic reactions, and biochemical processes, such as biodegradation and bioaccumulation.

Definitions of the factors affecting environmental fate and transport of chemicals, such as solubility, partition coefficients, etc., are presented in Appendix O.

5.1 Contaminant Characteristics

In this section, the chemical characteristics and available fate and transport data for organic and inorganic contaminants of potential concern are summarized. Each generalized contaminant class is discussed along with a summary of the anticipated environmental fate characteristics. Much of the information presented in this section is from USEPA, 2014a, 1996a, 1996b, 1986, and 1979; and Clement Associates, 1985, in addition to other sources, to which the reader is referred for more detailed discussions of the chemical characteristics affecting the fate and transport of the on-site contaminants of concern.

Chemical parameters for specific COPCs are provided in Table 5-1. Included in this table where available are density, water solubility, vapor pressure and Henry's Law constants, adsorption factors (K_{oc} and/or log K_{ow}), diffusion coefficients in air and water, photolytic, hydrolytic, and biodegradation and biotransformation rates and bioaccumulation rates. Appendix O provides definitions/summaries of these principal factors affecting environmental fate and transport processes. Fate and transport tendencies of the multiple classes of organic compounds are summarized in a qualitative manner in Table 5-2. Relevant data for the metals are provided in

Table 5-3, including sorption/dissociation, bioaccumulation, and mobilization/immobilization factors.

5.1.1 Volatile Organic Compounds

The VOCs of potential concern detected in various matrices during the RI (Tables 5-1 and 5-2) have been segregated into halogenated and non-halogenated groups. Each of these classes will be discussed in the subsections that follow.

5.1.1.1 Halogenated Volatiles

Halogenated VOCs are a diverse group of organic compounds characterized by an open-chain or ring structure that has undergone halogenation. Industrial halogenation processes yield mono- or polychlorinated derivatives that are widely applied as solvents, degreasers, dry-cleaning agents, refrigerants, and chemical intermediates (Merck, 1990). Because of their widespread application in many industrial processes, chlorinated organics are generally present in the environment, particularly in urban/industrial areas, originating from numerous point and nonpoint sources. Their historical use as solvents/degreasers in facility operations, along with the potential for other facility uses has impacted media on the former FWEC Facility. Use of halogenated VOCs in other manufacturing and/or commercial processes, such as within the SIPs, also may have occurred.

Halogenated VOCs are mobile and not very persistent in the environment, principally due to their high volatility, low adsorption to soils, high aqueous solubility, and inability to substantially bioaccumulate (Tables 5-1 and 5-2). Because of these characteristics, the primary fate and transport mechanisms affecting halogenated VOCs are volatilization into the air and migration in groundwater. However, under certain conditions that restrict or eliminate these compounds' contact with the surface atmosphere, volatilization into the air will be of lesser importance. Examples of these conditions are: presence in deep soil strata or deep groundwater, overlying buildings, asphalt or concrete, dense packed soil or clay without interstitial voids. The high volatility of halogenated VOCs limits the extent of transport, since these constituents may volatilize out of unconfined water bodies. To a lesser extent, groundwater transport, specifically in the upper, partially confined portion of an aquifer, also may be lessened because of the compounds volatilizing into their surroundings.

The halogenated VOCs also tend to undergo degradation reactions in anaerobic and aerobic soil systems (Figure 5-1). The anaerobic degradation reactions involve the progressive loss of halogen ions from the molecular structure, resulting in stepwise dehalogenation. Aerobic degradation reactions involve opening the double bond structure, changing alkenes to alkanes, such as 1,1-DCE to 1,1-DCA, etc. These degradation reactions, involving the progressive loss of halogens and/or the opening of the double bond structure, generally result in a sequential increase in the mobility of the resulting compound(s) within environmental media. Thus, as shown in Figure 5-

1, as the reactions progress from top to bottom, the mobility also typically increases. The biodegradation of halogenated volatiles, however, is typically a very slow process that is primarily favored under anaerobic conditions.

As shown in Table 5-1, eleven halogenated VOCs have been identified as COPCs, with TCE being the principal contaminant. Based on their aqueous solubilities and densities, a majority of these VOCs will tend to concentrate in deeper soils and in the lower reaches of an aquifer, particularly downgradient of a source area and/or immediately above any confining layers. In contrast, vinyl chloride will tend to concentrate in the upper reaches of an aquifer, due to a density less than 1 g/ml. As a result of the attenuating characteristics of halogenated VOCs (e.g., high mobility and volatility resulting in dilution and dispersion, their ability to undergo degradation, etc.), a decrease in their concentrations is anticipated with time, as long as there is no additional input of these compounds.

5.1.1.2 Non-halogenated Volatiles

Seven non-halogenated VOCs have been identified as COPCs: 1,4-dioxane, acetone, benzene, ethylbenzene, formaldehyde, toluene, and xylenes. Non-halogenated VOCs are generally low molecular weight open-chain or single ring structures that are widely utilized as industrial solvents, degreasers, and chemical intermediates. Their widespread application in many industrial processes, and as normal components of petroleum products/fuels, such as benzene, toluene, xylenes and/or typical constituents of octane-boosting additives, results in their being common environmental contaminants originating from various point and non-point sources. 1,4-dioxane was historically utilized primarily as a stabilizer in chlorinated solvents, particularly 1,1,1-TCA. Currently, 1,4-dioxane has a variety of applications, including as a solvent for chemical processing, as a laboratory reagent, in plastic, rubber, insecticide, and herbicides, as a chemical intermediate, as part of a polymerization catalyst and as an extraction medium of animal and vegetable oils. It has been reported to be used in the production processes, or found in the finished products, of the following product categories: pharmaceuticals, detergents, soaps and shampoos, cosmetic products, pesticides, magnetic tape, and adhesives (ATSDR, 2012). Specific physicochemical characteristics of the non-halogenated VOCs of concern are listed in Table 5-1, and their environmental fate and transport behaviors are summarized in Table 5-2.

Groundwater transport of the non-halogenated VOCs is a principal environmental fate process. Compounds of this subclass generally are mobile and transient in environmental matrices due to their high volatility, high water solubility, especially 1,4-dioxane, acetone and formaldehyde with values in the 10^5 to 10^6 mg/L range, low adsorptive affinity to soils, and typically low bioaccumulation potential. As with the halogenated VOCs, when conditions restrict or eliminate these compounds' contact with the surface atmosphere, volatilization into the air will be of lesser importance.

Due to their densities being less than water (Table 5-1), most of these non-halogenated VOCs would "float" within the groundwater and tend to concentrate in the upper reaches of an aquifer, in contrast to the halogenated VOCs that generally have densities greater than water and would "sink" within the groundwater. The exception is 1,4-dioxane, which is completely miscible in water.

The non-halogenated VOCs are generally subject to more rapid biodegradation/ biotransformation processes than the halogenated VOCs, contributing to a low persistence in the environment. Again, 1,4-dioxane is the exception, being relatively resistant to biodegradation.

5.1.2 Semi-Volatile Organic Compounds

SVOCs consist of a number of chemical subclasses, and the COPCs detected in the various environmental matrices have been segregated into polycyclic aromatic hydrocarbons (PAHs) and "other" base-neutral extractable organics, such as phthalates and chlorobenzenes. Most are ubiquitous in industrial/urban environments, principally occurring as a result of various manufacturing processes, use in plastics (phthalates), fuel usage, and/or past utilization/disposal of products or raw materials containing these chemical constituents. Chemicals likely to have been historically handled in facility operations that contain base/neutral extractable compounds include fuel oils and various chlorinated solvents. Specific physicochemical characteristics of these SVOCs are listed in Table 5-1. Environmental fate and transport characteristics are summarized in Table 5-2.

5.1.2.1 Polycyclic Aromatic Hydrocarbons

PAHs are principal components of petroleum products, such as fuel, oil and grease, and petroleum combustion exhaust fumes (Merck, 1990). Although dibenzofuran and carbazole are not generally considered PAHs since they contain either oxygen or nitrogen incorporated directly in the heterocyclic ring structure, they will be addressed with the PAH compounds since their fate characteristics are similar to PAHs.

PAHs are relatively persistent in soil matrices. This is due primarily to their low water solubility, high affinity for organic matter and soil particles, and high resistance to hydrolytic, photolytic, and oxidative degradation. Those of lesser molecular size and weight are typically not as strongly sorbed and may migrate farther in the environment. Several of the compounds in this class also may persist in soil as a result of their slow microbial degradation. PAHs may exhibit bioaccumulation, however, this is usually an ephemeral effect for these constituents since most organisms have the ability to metabolize these compounds.

5.1.2.2 Other Base/Neutral Extractables

The transport of base/neutral SVOCs is highly variable as a function of molecular structure, degree of aromaticity, and presence and type of functional groups attached to the parent molecule. Solubility is positively correlated with molecular polarity, such as chlorine atoms on 1,2,4-trichlorobenzene, and negatively correlated with degree of aromaticity. Higher molecular weight also generally corresponds to a compound being more strongly sorbed to soils. Although SVOCs can volatilize, this transport is limited and assessed to be of minor importance as an environmental fate process. For other fate processes, chlorinated benzenes have very low susceptibility to photolysis, hydrolysis, or oxidation and are degraded very slowly by microbial populations. Phthalate esters are slightly more susceptible to photolytic and hydrolytic reactions and undergo degradation and/or metabolization relatively rapidly under most conditions (Table 5-2).

5.1.3 Pesticides

Chlorinated pesticides are man-made chemicals characterized by a cyclic structure and a variable number of chlorine atoms. Pesticides were first produced in the early 1940s after discovery of their insecticidal properties. Generally, production of pesticides peaked in the early 1960s, but production has decreased markedly in the last decades due to their extreme persistence and tendency to bioaccumulate (SC, 2009).

Physicochemical characteristics data for individual pesticides are presented in Table 5-1, and environmental fate and transport characteristics of chlorinated pesticides are summarized in Table 5-2. Chlorinated pesticides are typically highly persistent chemicals that strongly adsorb to soils, sediments, and organic matter, and sorption is the dominant environmental process affecting the fate of pesticides in the vicinity of the former FWEC Facility. As such, soils and/or sediments typically serve as sinks for pesticide residuals.

The relatively low water solubility of the chlorinated pesticides (Table 5-1) indicates that surface water and/or groundwater transport is not an important process for most of these compounds, and is only a likely mechanism affecting the fate of the more water soluble pesticides such as the delta-BHC isomer. However, transport of particles with strongly sorbed pesticides would increase the importance of this mechanism in surface water. Enhanced migration in groundwater due to co-solvent effects exerted by more mobile organic contaminants, if present, also may be possible. Very limited volatilization is expected, and the processes of photolysis, hydrolysis, oxidation, and biodegradation are not likely to be major factors in determining the fate of these compounds (Table 5-2). Most chlorinated pesticides exhibit significant bioaccumulation, with bioconcentration factors (BCFs) in fish (Table 5-1). The BCFs generally refer to fish in direct contact with pesticide-contaminated water. The lack of suitable habitat for fish over most of the former FWEC Facility, the SIPs, and the Affected Area directly precludes this as a possible environmental fate. However, bioaccumulation within other terrestrial and aquatic organisms would likely be of importance for these compounds.

5.1.4 Polychlorinated Biphenyls

PCBs are highly persistent chemicals that strongly adsorb to soils, sediments, and organic matter, and sorption is the dominant environmental process affecting the fate of PCBs. As shown in Tables 5-1 and 5-2, due to the relatively low water solubility of these chemical compounds, dissolution is typically not a principal fate process, except in the presence of more mobile VOCs and/or humic/fluvic acids in the waters. Transport of small particles with strongly sorbed PCBs may occur. Limited volatilization of PCBs from contaminated matrices can occur, and would primarily involve chlorinated PCB compounds with fewer chlorine atoms, which were not detected during the RI.

The processes of photolysis, hydrolysis, oxidation, and biodegradation are insignificant factors in determining the fate of these compounds (Table 5-2). PCBs may undergo photolysis in the atmosphere, where they react with photo-chemically produced hydroxyl radicals. However, this is a slow process, particularly for the highly chlorinated congeners. In addition, PCBs are strongly bonded compounds that are not readily hydrolyzed. These compounds also are relatively resistant to oxidation under normal environmental conditions. The PCBs of potential concern are resistant to biodegradation and biotransformation, although degradation can occur at an extremely low rate.

PCBs are bioconcentrated in terrestrial plants and terrestrial and aquatic organisms to relatively high levels in some species. Algae and terrestrial macrophytes, invertebrates, fish, reptiles, birds and mammals can all be affected (PWRC, 2002). Although PCBs exhibit significant bioaccumulation in fish, the surface water bodies within a majority of the former FWEC Facility, the SIPs, and the Affected Area are not suitable habitat for fish, with the exception of the lower channel of Watering Run (Section 3.6.4).

5.1.5 Inorganics (Metals and Cyanide)

Numerous metals and cyanide were detected in the various matrices sampled at the former FWEC Facility, within the SIPs and/or the Affected Area. Many of these metals are normal constituents of soil parental material and uncontaminated regional groundwater. This section focuses only on summarized environmental fate data for those metals exhibiting atypical environmental concentrations that were identified as COPCs and/or chemicals of potential ecological concern (COPECs). Tables 5-1 and 5-2 contain characteristics values and summaries for cyanides. Table 5-3 presents environmental fate and transport data for the metals.

5.1.5.1 Metals

Unlike the organic compounds discussed in preceding sections, the metals are difficult to discuss in terms of behaviorally similar groups. The environmental behavior of individual metals has been widely studied, and the characteristics of specific metals are better understood than those of individual organic compounds. However, it is difficult to distinguish between naturally-occurring and introduced metals, particularly in the case of geochemical analytes such as aluminum, iron, barium and manganese. Additionally, many of the fate and transport mechanisms that may be important for organic compounds have little influence on the metals. Volatilization, under special conditions, only applies to a select few metals or metallic compounds, such as mercury and some organo-metallic compounds. Photolysis is of negligible importance to the environmental behavior of metals and most metallic compounds. Fate and transport profiles of the individual metals of concern are presented in Appendix P.

The most important factors controlling metal fate and transport are solubility, redox behavior, aqueous speciation and complexes, such as metal sulfides versus metal sulfates, and sorption behavior, all of which are functions of the ambient geochemical environment. In general, metals are persistent and of limited mobility within environmental matrices under normal environmental conditions. This persistence is primarily related to recycling mechanisms within environmental matrices for some metals such as arsenic and lead, and removal mechanisms such as precipitation, cationic exchange, adsorption, etc., which decrease mobility and generally result in the metals remaining within soil and/or sediment matrices. Chemical speciation of metals in the environment results in metals in both solid and aqueous media. However, the fate reactions and the behavior of these metals under Site geochemical conditions may lead to an increase or decrease in their concentrations in specific matrices.

Metals typically have a high adsorptive affinity for inorganic mineral surfaces and organic matter. Adsorption, for most metals, is highly pH-dependent, with desorption occurring at a low pH and sorption mechanisms occurring at higher pH conditions. However, the types of clays present and their surface charges, in relation to soil pH values, dictate whether sorption or desorption will occur. Additionally, chemical speciation determines the relative degree of adsorption among different species of a particular metal. Based on the data available for Site soils, sorption is most probably a significant fate process for potential metallic contaminants of concern. Aerobic conditions in surface water and shallow groundwater are likely to promote the precipitation of ferromanganese oxides and oxyhydroxides, where other metals will readily adsorb.

The mobility of metals within environmental matrices depends upon numerous factors such as the relative stabilities of individual valence states that are element-specific, oxygen content, pH and Eh conditions, and the presence of available complexing agents (Table 5-3). The expected predominant dissolved species or minerals of the metals in aqueous systems may be predicted from geochemical equilibrium models expressed in Eh-pH diagrams. However, such predictions are speculative and will not be attempted or presented here.

In addition, metals are, to variable extents, subject to cation-exchange reactions with minerals present in the environment. The extent that cation-exchange occurs is dependent on the mineral species present and on pH, as well as on the characteristics of the individual metals. As mentioned previously, volatilization and photolysis are of limited importance. Biotransformation processes can be important for some metals, such as arsenic, copper, lead, and thallium, under certain environmental conditions.

5.1.5.2 Cyanides

Total cyanides were sporadically detected during the RI and are considered COPCs/COPECs for surface soils and groundwater on the former FWEC Facility, and sediments and seep/spring water in the Affected Area. It is important to note that cyanides consist of a diverse group of compounds such as free hydrogen cyanide or cyanogen, metallo-cyanides/cyanates/isocyanates/thiocyanates, nitriles, and/or cyanohydrins. However, the exact species of cyanide present was not determined by the analytical method used, since the collected samples were only analyzed for total cyanide. Since the exact species of cyanide is currently unknown, the discussion that follows addresses all potential species, which may not actually be present on-site. Data affecting the environmental fate of cyanides is presented in Table 5-1, and relevant characteristics for cyanides are summarized in Table 5-2.

The cyanide functional group (-CN) can exist in a diverse group of organic or inorganic compounds. As summarized in Table 5-2, most cyanide compounds are typically mobile and not very persistent in the environment due to their high volatility, high reactivity, high aqueous solubility, low adsorption to soil, low bioaccumulation potential, and susceptibility to microbial, metabolic, photolytic and hydrolytic degradation. However, since many of these compounds can be converted to other cyanide-containing compounds during assorted degradation/decomposition reactions, various forms may exist for some time in the environment, particularly if insoluble and/or stable cyanide-containing compounds are produced.

5.2 Release Mechanisms and Potential Routes of Migration

Constituents may migrate from specific or multiple source areas through a variety of mechanisms. The importance of a given migration process is controlled by the specific physical, geochemical, hydrogeologic, and climatic conditions at the Site, as well as by the physicochemical characteristics of the constituent and the impacted media. The environmental characteristics of the geology and soil type, geochemistry, hydrogeology, and climate were described in detail in Section 3.0. The potential migration pathways and associated mechanisms of migration for the Site are as follows:

- Migration of constituents from potential source areas to environmental media via infiltration and leaching, erosion/runoff, wind re-suspension and dispersion, and/or volatile diffusion and dispersion;

- Percolation and migration of constituents into groundwater via infiltration and leaching;

- Migration of contaminated groundwater;

- Migration of constituents to/within transitory, perennial or permanent surface water bodies and sediments via erosion/runoff, infiltration and leaching, and/or groundwater recharge;

- Migration of constituents into freshwater/terrestrial biota via wind re-suspension and dispersion, erosion/runoff, and/or infiltration and leaching; and

- Migration of constituents into and through air via wind re-suspension and dispersion, volatile diffusion and dispersion, and vapor intrusion.

The importance of the pathways mentioned above to the classes of constituents found during the RI is discussed in the following subsections.

5.2.1 Migration of Contaminants from Potential Source Areas to Environmental Media

Matrices within and/or surrounding the former FWEC Facility have been impacted in the past due to storage and/or material handling operations used during historic operations.

As a consequence of these activities, multiple potential or known sources of contamination existed on the property (Section 1.4.2). Localized areas of impacted soil still remain, such as in the former vapor degreaser area and, to a lesser extent, the former finish paint building/solvent and paint storage buildings area. Chemicals from these potential sources may migrate within and/or into the surrounding environment in several ways.

Other areas of industrial activities/operations also may have generated additional sources outside the former FWEC Facility. Investigation results also indicate a potential TCE contaminant source identified in the vicinity of the Fabri-Kal facility located west of the former FWEC Facility and a potential TCE contaminant source identified in the area of the CertainTeed and Bergen Machine facilities located south of the former FWEC Facility. Site data also indicate that groundwater contamination originating south of the former FWEC Facility, in the area of the CertainTeed and Bergen Machine facilities, might be migrating locally in a northerly direction onto the Facility as a function of groundwater gradients induced by the currently operating extraction wells.

As described below, chemicals from onsite and off-site sources may migrate within and/or into the surrounding environment in several ways. As site-specific data on the near-surface conditions of the Fabri-Kal, CertainTeed, and Bergen Machine facilities are limited, the majority of the following discussions is focused on the former FWEC Facility property.

Impacted soil areas contain constituents that were transported into underlying soils and groundwater by the percolation of rain, dissolution in groundwater, and/or gravity. The primary COPCs, halogenated VOCs, are generally not persistent within soil matrices, due to their high aqueous solubilities and low adsorptive affinities. Data from previous investigations and the current RI indicate TCE above screening criteria in the former vapor degreaser area in the surface soils to depths up to 17 feet bgs. Other COPCs/COPECs, such as PAHs, PCBs and metals, are generally more persistent and of limited mobility within soil matrices under normal environmental conditions. Upon entering groundwater, constituents have migrated with the groundwater flow and entered surface water bodies in the form of seeps and springs.

Based on the surface topography at the former FWEC Facility, which is relatively flat, and the moderately porous nature of the underlying soils, surficial water most likely has drained through percolation, with limited amounts being directed into the unnamed surface feature draining into Watering Run to the south and a minor amount into Bow Creek to the north. Storm events and/or significant snowmelt also have generated sufficient energy for more substantial migration of surficial contamination, either as dissolved components or fine particulates. Lateral spreading is expected to be non-existent or minimal in vegetated areas, and only a probable scenario within unvegetated areas. A majority of the former FWEC Facility is vegetated, with other areas covered with the remnants of buildings/structures, such as former concrete footprints, which also reduces the entrainment of shallow soil particulates in surficial run-off.

Dry, windy weather may result in the entrainment of soil particles from exposed impacted surficial soil sources into the atmosphere, with subsequent deposition. As vegetation or other cover is present over a majority of the former FWEC Facility, the possibility of airborne entrainment of impacted shallow soil particulates is significantly reduced. To a limited degree based on soil type and depth of soil impact, volatile constituents may volatilize from these matrices and be emitted into the atmosphere and subsequently transported by prevailing winds. It is likely that each of the above processes has occurred to some degree in the past and is continuing to occur.

5.2.2 Percolation and Migration of Constituents into Groundwater

COPCs detected in soils may migrate from surficial to deeper subsurface soils, and eventually into groundwater by the percolation of rainwater through the impacted soils. Dissolved phase entrainment of constituents within percolating groundwater can primarily occur through direct dissolution of constituents from soils into the percolating water. Other mechanisms may include dissolution into more water soluble organic compounds already entrained within the percolating rainwater, due to co-solvent effects or, to some extent, transport of very fine particulates, such as colloids, where chemical constituents are adsorbed. It is possible that each of these processes has occurred to some relatively minor degree in the past and is continuing to occur.

SVOCs, pesticides and PCBs are not readily transported through soil due to their generally low aqueous solubilities and high adsorptive affinities. In addition, they were present only at relatively low concentrations in soil samples collected during the RI.

The transport of metals into groundwater is a function of the solubility (and related leachability) of a given metal in a specific water mass under specific conditions. Transport of metals into groundwater typically involves dissociation of metallic cations from a source material into the groundwater. However, it also may occur, to some extent, with particulate phases where the metals are adsorbed. In water-bearing zones, transport of particulates is principally limited to colloid-size particles, with extremely small particles, generally defined as less than 0.7 mm in diameter, or particles smaller than the available pore space. Larger particles cannot pass through water-bearing zones because of their size, which is generally larger than pore space, and because the energy of the water that is slowly percolating through the ground is usually insufficient to carry particles larger than colloids in suspension. Since the on-site soils are primarily silts and clays, little particulate transport is expected to have occurred, and any that may occur would be for only limited distances.

Total metals groundwater concentrations appear to be related primarily to percolation of rainwater through the overlying parent soil material to groundwater. The observed distributional pattern for the metals does not imply that metals, as a whole, are migrating from suspected potential source area(s). At least a portion of the detected concentrations of metals may be indicative of natural presence of metals in the area. Section 4.0 provides further discussion on the nature of the metals occurrences. The concentrations of metal constituents in overburden groundwater near MIP Area #2 location B30 were more elevated than the concentrations found elsewhere during the RI, which may indicate a more localized condition with respect to migration into groundwater.

5.2.3 Migration of Impacted Groundwater Off-Site

Groundwater that has or may become impacted as a result of overlying contaminated soil or other potential source areas located on or off the former FWEC Facility has migrated through overburden and bedrock. Migration of constituents in groundwater is controlled principally by two processes: advection and dispersion. Advection is the process where dissolved constituents are transported by the bulk motion of groundwater flow. Dispersion is the spreading of dissolved constituents as they move with groundwater as a function of molecular diffusion and mechanical mixing. Both advection and dispersion act on constituents in solution. Constituents associated with large solid phases generally are not transported by groundwater. However, some limited transport of very fine particles, such as colloids, may occur.

As presented in Section 3.5.2, local groundwater flow on and near the former FWEC Facility is generally to the south-southwest, while groundwater in the Affected Area flows to the west. The groundwater flow direction is primarily influenced by topography and soil-bedrock surface morphology and rainfall patterns. Constituents originating in source areas that then enter groundwater will migrate within the groundwater to other hydrologically downgradient areas following the local groundwater flow direction. Based upon historical and current RI groundwater data, principal COPCs that are migrating within the overburden and/or bedrock groundwater at a minimum include halogenated and non-halogenated VOCs, with TCE as the predominant constituent.

The GETS uses four on-site wells, two near the former vapor degreaser source area and two near the former FWEC property's southern boundary. The extracted groundwater is treated, removing TCE and other volatile constituents, prior to discharge of the treated effluent to the headwaters of Watering Run. Operation of the system affects groundwater flow in the vicinity of these wells, as evidenced by lower groundwater elevations during the groundwater elevation measurement events (see Section 3.5.2). Thus, the migration of impacted groundwater also would be impacted by this process. As discussed in more detail in Section 6.0, investigation data indicate that groundwater contamination potentially originating in the area of the CertainTeed and Bergen Machine facilities might be migrating locally in a northerly direction onto the former FWEC Facility property as a function of groundwater gradients induced by the currently operating extraction wells.

Based upon physicochemical characteristics, VOCs would be expected to migrate the farthest, primarily due to their high aqueous solubilities and low adsorptive affinities, until diluted to below detection limit values. Based on the physical and chemical properties of 1,4-dioxane, this compound may migrate more rapidly in groundwater, ahead of other constituents (USEPA, 2006).

Metals in groundwater, particularly if present as ionic species, would be expected to migrate a considerable distance with the groundwater flow until they are adsorbed by surrounding soil particles. Metals also may be transported with very fine suspended particulates and/or colloidal matter to which they are adsorbed. In view of the relatively porous nature of the Site media where groundwater is flowing, this type of groundwater transport could occur, although at a more limited distance.

Based on the general physicochemical characteristics of the constituents and the detected occurrences of site-related COPCs/COPECs, migration within groundwater will be the primary transport mechanism at the Site, predominantly for VOCs. Migration of contaminants in groundwater will be controlled principally by groundwater flow and dilution effects, and contaminant removal mechanisms such as adsorption, equilibrium dissolution-precipitation conditions, biodegradation, and for some constituents, limited volatilization from groundwater into interstitial voids within the overlying vadose zone soils.

5.2.4 Migration To/Within Surface Runoff and Permanent Surface Water Bodies/Sediments

Impacts to surface water and/or sediment may occur, or have occurred, as a result of historic practices used during past operations, by transport of impacted material through surface runoff, or through further migration within water bodies to downstream locations within the water column or sediment bed load. Transport of impacted material in the sediment load is controlled by physical processes and is dependent on the rate of flow, which determines the sediment load capacity of the water body. In more stagnant bodies of water, impacted sediments will accumulate without further significant transport. Higher flow rates increase the ability to transport sediment away from sources. In contrast to sediment transport, transport of dissolved components, such as in surface and/or pore waters, is a chemical process, generally controlled by the rate of release of the constituent from the source, by the solubility of the constituent, and by the rate of influx of impacted media. The amount of constituent transported is a function of the equilibrium dissolution and precipitation conditions of both the constituent and the water system.

Surface water drainage at the former FWEC Facility directs storm water and snowmelt surface runoff to the unnamed surface feature draining into Watering Run to the south, and a minor amount to Bow Creek to the north. It is important to note that water flow within these areas is transitory, with no or little water present during low rainfall and snowmelt periods. During storm and/or snowmelt events, constituents may become solubilized in surface runoff from underlying impacted soil and transported via these drainage features. Additionally, the wetlands and ephemeral streams also may transport constituents received from recharging groundwater, particularly during low rainfall and drought conditions. The distance from the sources and impacted soils to these areas and/or the wetland area may exclude this type of transport from importance, since MIP Areas #1 and #2 are more than 500 feet away from either of the on-site wetlands and pond or the southern drainage to Watering Run. However, their distance does not preclude the possibility of impacted groundwater discharge to the surface water and wetland bodies.

During surface runoff transport, some infiltration of impacted runoff and ephemeral stream water and limited subsequent adsorption of constituents to the underlying sediments and/or soils during infiltration may occur along storm water and snowmelt surface runoff routes. If the storm water or snowmelt runoff flow is sufficient, impacted soil also may be transported from the non-vegetated on-site areas to these storm water receiving bodies. Both of these transport processes are considered of minor consequence for the Site.

South of the former FWEC Facility property boundary, Watering Run turns towards the west and generally flows west through the Affected Area, draining into the Susquehanna River, located approximately 12 miles west of the Site. Watering Run currently has perennial flow resulting from discharge of treated groundwater effluent. Previous natural conditions indicate ephemeral or perennial flow depending on the amount of in-flow from seeps, tributaries, and surface drainage.

Once within Watering Run, further migration may occur to downstream and/or adjacent areas within the water column, or to a lesser extent, the sediment bed load.

Migration via groundwater discharge to the overlying surface water and low-lying areas occurs at several seeps located in the Affected Area. TCE was detected in seep locations SW-17 and SW-23, with lower, more sporadic detections in Watering Run and tributaries. Pore water collected from these locations contained TCE. Corresponding sediment levels for TCE in the two seep locations were either below screening criteria or not detected. The data indicate the site-related constituents, when found, are primarily in the water column and are more likely a result of upwelling of impacted groundwater than dissolution and transport.

5.2.5 Migration of Constituents into Freshwater/Terrestrial Biota

Habitats identified during the RI include upland terrestrial, intermittent headwater riparian/wetlands, and perennial aquatic habitats in Watering Run and tributaries. Once constituents impact these habitats, biota present therein may accumulate these constituents directly through bioconcentration or indirectly by bioaccumulation through the food chain. Migration of COPCs/COPECs into biota is considered a viable potential pathway because of the indigenous populations of soil and benthic invertebrates, terrestrial and aquatic plants, fish, and terrestrial wildlife observed during the RI. Details on the potential ecological receptors specific to the habitats are described in more detail in the SLERA (Appendix L).

The halogenated VOCs of concern, and many of the non-halogenated VOCs, do not appreciably bioaccumulate (Table 5-1), further reducing the potential significance of this migration pathway for these constituents. Further, VOCs, including TCE, would be expected to dissipate rapidly from surface water or surface soils via volatilization.

Bioconcentration and bioaccumulation of other COPCs/COPECs is constituent-specific. Generally for SVOCs, the greater the number and complexity of rings, the greater is the potential for substantial bioaccumulation to occur. PAHs typically exhibit the highest BCFs. However, bioaccumulation of PAHs is a transitory process, since most PAHs with less than five rings are readily metabolized by higher organisms under most conditions. Based on fish BCFs and organism depuration rates, pesticides, PCBs, mercury, silver, thallium, and zinc may exhibit bioaccumulation in terrestrial and/or aquatic organisms (Tables 5-1 and 5-3). The low detections and limited occurrences for these other COPC/COPECs further reduce the potential significance of this environmental transport mechanism.

5.2.6 Migration of Constituents in Air

Constituents may be transferred into air via two distinct emission mechanisms: volatilization (primarily of organic compounds through diffusion) and dispersion and entrainment of impacted particles by the wind (such as fugitive dust emissions with wind re-suspension and dispersion). VOCs can migrate into air from contaminated surface soil, or from contaminated shallow subsurface soils or groundwater. Volatilization from surface soil is essentially unrestricted, and as such, is governed only by the physicochemical characteristics of a given constituent under ambient conditions. Volatilization from subsurface media is more complex and is influenced by factors such as soil moisture and soil permeability. The extent of particulate entrainment at a Site is governed in large part by climatic and weather conditions, such as the frequency of dry, windy periods that are more conducive to surface soil entrainment than wet, quiescent conditions. Other factors that affect the entrainment of particulates include the activities that occur or have occurred on the Site, the extent of vegetated areas, and the grain size distribution of the surface soil.

Currently at the former FWEC Facility, a majority of the property is covered by the remnants of buildings and structures, vegetated areas, and roadways that are paved, dirt, and/or gravel. Exposed, non-vegetated soil is present in very limited areas and is conditional on season, weather and other factors. Depending on the location, these areas may contain impacted surficial soil. The airborne entrainment of impacted soil particles is expected to be a viable environmental transport mechanism for select COPC/COPECs in only a few limited, localized areas, and to be of little potential significance over the rest of the former FWEC Facility. This process would only occur in those impacted areas devoid of vegetation, primarily during dry, windy days. Volatile emissions, with their concomitant dispersion via the prevailing wind, would be a viable transport mechanism onto some areas of the former FWEC Facility and the Affected Area, as well as the SIPs. However, considering the vegetative cover over any undeveloped areas, the small areal extent of the potential source areas on the former FWEC property, and the relatively low concentrations of VOCs detected in shallow on-site matrices, volatile emissions into the ambient air are not considered to be a pathway of concern within or from the Site.

VOCs may migrate from impacted shallow subsurface soils on the former FWEC Facility or the upper interval groundwater into interstitial voids, and then further diffuse through building foundation cracks or porous building foundations and enter existing structures. This process is called vapor intrusion. A comprehensive VI evaluation was performed at the residences and public buildings within the Affected Area that were identified in the Work Plan as having the greatest potential for VI, based on an assessment of the distribution and concentrations of TCE in the groundwater beneath the Affected Area at that time. Details of the VI investigation are provided in the BHHRA, Appendix M. Based on the results of the VI investigation and mitigation activities, vapor intrusion is not considered to be a pathway of concern.

5.3 Trends in Historic Data

Statistical trend analysis was not performed for the monitoring wells sampled at the Site during the RI, due mainly to insufficient data rounds for the calculation using the non-parametric Mann-Kendall Statistical Test, where the test requires at least four separate sampling events. In addition, the majority of the RI groundwater data were collected over a relatively short period of time, since the three large scale groundwater sampling events were conducted over a period of less than one year, from May 2013 to April 2014. Variants in these data are more likely to represent seasonal variations rather than long-term trends. Therefore, a qualitative evaluation was performed to identify general trends in contamination levels for the former FWEC Facility, SIPs, and the Affected Area. The evaluation was performed for TCE, the primary constituent of concern at the Site, and the only site-related constituent detected in a majority of the wells sampled during the RI. Historical data presented in the DGAR, as well as data collected during the RI, were included in this evaluation.

5.3.1 Former FWEC Facility

Historic data for the former FWEC Facility, as reported in the DGAR, indicated detections of TCE in 436 out of 607 samples collected, with a maximum concentration of 180,000 ug/L (Table 5-4). Of the detected concentrations, 360 exceeded the MCL of 5 ug/L. Historic sampling was conducted from the 53 monitoring, recovery, or observation wells installed at the former FWEC Facility over approximately 20 years of investigation and monitoring of the effectiveness of the groundwater extraction and treatment system (circa 1989 through 2008).

During the RI field investigation activities, samples were collected from monitoring wells on the former FWEC Facility during the interim overburden groundwater sampling event (Section 2.11.3) and groundwater sampling rounds 1, 2 and 3 (Sections 2.11.6, 2.11.7 and 2.11.9). TCE was detected in 61 out of 81 samples collected on the former FWEC Facility, with a maximum concentration of 4,900 ug/L at MD-01 observed during the Round 2 sampling event. As shown in Table 5-4, TCE concentrations exceeded the MCL of 5 ug/L in 25 samples over the course of the RI.

These data indicate a significant downward trend in the concentration of TCE at the former FWEC Facility. To illustrate this position, historic and RI data from three facility wells, MW-2, MW-4 and MW-7S, were graphed, and a linear trendline plotted (Figure 5-2). As shown in these three examples, TCE has fluctuated in concentration through the years of monitoring but a general decreasing trend is evident. Groundwater monitoring data associated with the operation of the groundwater treatment system also show a long-term downward trend in TCE concentrations in nearly all of the monitored wells on the former FWEC Facility, as depicted on Figure 4 of Progress Report #82 for the IRM (URS, 2014). A copy of this figure is provided in Appendix B.

5.3.2 Surrounding Industrial Properties

Ten monitoring wells were installed by USEPA and FWEC at six locations on and in the vicinity of certain of the SIPs. As reported in the DGAR and shown in Table 5-5, historic data collected from these USEPA and FWEC monitoring wells using packer, diffusion bag and low-flow methodologies during 2005 (all ten wells) and 2007 (five of the ten wells) indicated detections of TCE in 44 out of 63 samples, with a maximum concentration of 290 ug/L. Of the 44 detected concentrations, only 6 exceeded the MCL of 5 ug/L.

During the RI field investigation activities, samples were collected from these same monitoring wells and also additional monitoring wells installed within the SIP area, in accordance with the RI/FS Work Plan. Over the course of the RI sampling events, TCE was detected in 86 out of 105 samples collected within the SIPs, with a maximum concentration of 310 ug/L at RMW-01D-01 observed during the Round 3 sampling event. Seventy-seven (77) samples contained TCE concentrations above the MCL of 5 ug/L (Table 5-5).

Concentrations in the USEPA/FWEC monitoring wells have not significantly declined in magnitude between the historic and current sampling events. In addition, the concentrations detected in the newly installed wells in the SIP area are of similar magnitude. Although the data are insufficient to determine concentration trends at individual wells, Table 5-5 and Figure 5-3 demonstrate that the degree of groundwater impact, as illustrated through maximum concentrations at similar depth intervals for wells in the same portion of the SIP area, is relatively stable. As shown, the detected levels in the newly installed wells in the SIP area are of generally similar magnitude as the historical wells, with a slight increase noted in the TCE concentrations from select new wells. These detections support the proposition that additional localized sources affecting groundwater quality and attenuation of TCE may be present within the SIP area at certain locations as discussed earlier in this report.

5.3.3 Affected Area

Historic data for the residential wells (approximately 150 locations), as reported in the DGAR, indicated detections of TCE in 431 out of 767 samples collected, with a maximum concentration of 270 ug/L. These samples were collected from 2004 through 2007 prior to treatment with carbon-filtration systems. Of the detected concentrations, 321 exceeded the MCL of 5 ug/L.

During the RI field investigation activities, samples were collected from newly-installed monitoring wells, seeps/springs, and sentinel well locations during several of the sampling events. TCE was detected in 72 out of 88 samples collected within the Affected Area, with a maximum concentration of 110 ug/L at RMW-09S-1 observed during the Round 3 sampling event (Table 5-6). As discussed in Section 2.11.10, the TCE concentration of 110 ug/L observed at RMW-09S-1 during the Round 3 sampling event was not consistent with prior results at this location. An additional sample collected from this well on October 14, 2014 indicated a TCE concentration of 0.27J ug/L, suggesting that the prior result of 110 ug/L was an anomaly. Excluding that anomalous result, the maximum concentration observed during the RI in the Affected Area was 86 ug/L, which was present at both RMW-09S-2 and RMW-09D-1, during the Round 1 sampling event. Within the Affected Area, TCE concentrations exceeded the MCL of 5 ug/L in 51 samples.

Overall, the TCE concentrations detected during the RI sampling events are generally lower than the historic values measured in residential wells. This indicates that concentrations of TCE in groundwater in the Affected Area are declining as a result of natural attenuation processes and the operation of the GETS at the former FWEC Facility. This declining trend is illustrated in Figure 5-4, which compares data from historic residential locations along Church Road and South Mountain Boulevard to RI monitoring wells in the near vicinity.

5.4 Summary of Migration Trends

Based upon the local groundwater flow direction, generally south-southwest to west, and groundwater quality data, constituents in groundwater originating from the various suspected potential source areas at the former FWEC Facility, and in the vicinity of the CertainTeed, Bergen Machine and Fabri-Kal facilities, have migrated, and will continue to migrate until dilution and removal mechanisms such as adsorption, degradation, precipitation, and limited volatilization result in their eventual non-detection and/or until the impacted groundwater discharges to the seeps/springs and/or Watering Run. Operation of the interim GETS affects groundwater flow, and consequently migration of impacted groundwater, across the former FWEC Facility's southern boundary. The cones of depression for Recovery Wells RW-2R and RW-3, located in the vicinity of the southern FWEC Facility boundary and in close proximity to the CertainTeed property, are shown on Figures 3-7A, 3-7B, and 3-7C. Based on these observed cones of depression, groundwater extraction at the former FWEC Facility might be drawing contaminants from the CertainTeed property onto the former FWEC Facility property.

Vertically, groundwater data also show site-related constituents have migrated to and within the bedrock via fracture flow to depths greater than 300 feet bgs, with concentrations significantly decreasing with increasing depth. Based upon physicochemical characteristics, VOCs and dissolved metals would be expected to migrate the farthest in groundwater, while other organic constituents and metals associated with fine particulates are expected to migrate with the groundwater flow for only a limited distance.

Among the COPCs associated with the Site, the highly mobile VOC constituents are expected to exhibit the least persistence in impacted matrices, being lost rapidly due to volatilization and, to a lesser extent, biodegradation. As a direct result of their contaminant fate characteristics and the likely fate/transport mechanisms and natural attenuation processes, concentrations in environmental media are expected to continue diminishing over time as long as no new sources introduce additional contamination in the future. In contrast, the other COPCs/COPECs, such as SVOCs, pesticides, metals, cyanides, although present at significantly lesser concentrations during the RI, may be more persistent.

The migration of constituents from impacted areas/soil matrices to groundwater, and then within groundwater following the local flow direction, is the principal environmental fate and transport mechanism for the Site. Data collected historically and during this RI indicate groundwater under the former FWEC Facility, six of the eight SIPs, and the Affected Area has been impacted. Subsequent upwelling of impacted groundwater into seep/spring areas, wetland and pond areas, and/or into Watering Run and tributaries also is an environmental fate and transport mechanism, based on the physicochemical properties of the constituents of concern, the hydrogeologic conditions, and data collected during the RI.

Comparison of historic and RI results for monitoring wells on the former FWEC Facility showed a decline in concentration of approximately two orders of magnitude (Figure 5-2). Groundwater concentration levels in the Affected Area also indicated a decline (Figure 5-4). The concentrations detected in the vicinity of the SIPs do not appear to have declined in magnitude between the historic and current sampling events (Figure 5-3). Based on these concentration trends, fate/transport processes appear to be gradually reducing constituent occurrence within the groundwater plume, although to a lesser extent at the SIPs, which may be related to the identification of other potential sources in the vicinity of the CertainTeed, Bergen Machine and Fabri-Kal facilities. The extent that any one attenuation process, such as dilution, advection, dispersion, degradation, matrix diffusion, etc., is predominant cannot be determined with the available data, although the existing GETS contributes to constituent mass removal at the former FWEC Facility.

Accumulation in plants and/or organisms will be of little, if any, importance for the halogenated and non-halogenated VOCs. The significance of this route increases, although is still not of significance overall for the Site, for the other COPCs/COPECs such as PAHs, pesticides, PCBs, and select metals. Vapor/air entrainment also is not an environmental transport mechanism of concern, as the majority of the former FWEC Facility property is vegetated or covered and/or there are only limited occurrences of VOCs in the surface/near surface matrices. However, should intrusive activities occur in the future at the isolated areas of elevated concentrations, the importance of the air route of migration would increase by the generation of emissions or dust.

6.0 CONCEPTUAL SITE MODEL

This section summarizes the overall findings of the RI field investigation, including the results of the spatial modeling effort, performed as described in Section 2.16.2. Integrated visualizations of geologic, hydrogeologic and TCE data provide key findings that form the basis for the refined CSM.

6.1 Analysis of Data Collected During the RI

The following are key observations developed from an analysis of data collected in the RI.

- Exhibit 6-1 shows the Site, including the former FWEC Facility and the Affected Area, and surrounding areas. Also shown are the groundwater wells that were used in the plume delineation effort.
- Exhibit 6-2 shows that the geology of the Site and surrounding areas is comprised of two primary stratigraphic units – overburden and bedrock. The overburden consists of unconsolidated glacial till and minor occurrences of fill in the SIPs area. The till is underlain by two types of incompetent bedrock – weathered bedrock underlain by highly-fractured bedrock. Less fractured, competent bedrock underlies the incompetent bedrock. The presence and thickness of the till and the weathered bedrock varies across the Site and surrounding areas.
- Exhibit 6-3 shows a plan view of the water table surface at the Site, based on a 10 foot iso-elevation contour interval. Also shown are primary flow directions and the locations and indications of drawdown from the remedial extraction wells operating on the former FWEC Facility property.
- Exhibit 6-4 is an expanded plan view of the water table surface at the former FWEC Facility showing the locations and indications of drawdown from the remedial extraction wells operating on the property.
- Exhibit 6-5 is an expanded side view of the water table surface at the former FWEC Facility looking toward the Northwest, showing the locations and cones of depression from the remedial extraction wells operating on the former FWEC Facility property. This exhibit also provides an expanded view of various groundwater wells, well screen intervals and analytical results, as well as groundwater elevations and iso-contours.

Mapping of the TCE plume was conducted using Round 1 monitoring data for the wells shown in Exhibit 6-1, which were collected in May 2013, with select additional samples collected in October 2013. The program utilized for the depictions was C Tech Development Corporation's Mining Visualization Software (MVS). MVS provides a 2D rendition of the plume using wells in each, respective stratigraphic unit: overburden till and bedrock (including weathered and fractured bedrock). The maximum TCE concentration detected in each well was used when multiple depths within the same stratigraphic unit were sampled. The technical team adjusted the interpolated TCE surface for site specific conditions that the modeling program is unable to incorporate. These adjustments are indicated by dashed lines in the plume outline. Such site specific conditions include physical barriers (e.g., stratigraphy) and other physical influences such as groundwater gradient and direction, soil chemistry and bedrock weathering and fracturing.

- Exhibit 6-6 shows a plan view of the TCE plume in the shallow overburden till at 5 µg/l and greater than10 µg/l. An area of contamination is present within the shallow portions of the till in the vicinity of the CertainTeed and Bergen Machine facilities. A second area of contamination within the shallow portions of the till is located adjacent to the Fabri-Kal facility. These findings suggest that sources of TCE contamination, in addition to the former FWEC Facility, may exist at these facilities. A larger area of contamination within the till is located further downgradient near the western boundary of the historical Affected Area. Based on the presence of groundwater discharge seeps/springs and the lack of other potential TCE sources, this area of contamination is likely the result of contamination migrating from the former FWEC Facility, and may also be the result of contamination migrating from the other above-mentioned facilities.
- Exhibit 6-7 shows a plan view of the TCE plume in the weathered bedrock and underlying highly-fractured bedrock at 5 µg/l, 10 µg/l, 100 µg/l, 1,000 ug/L and greater than 1,000 µg/l. The plume originates at the former FWEC Facility, flows in a southwesterly direction, exhibits a pronounced directional shift in the vicinity of the CertainTeed facility, and flows westerly through the Affected Area to the western portion of the Site. The plume is generally narrow in width and migration is predominantly via advective transport with relatively limited lateral dispersion. Within the valley floor, the plume manifests at the surface in several locations in the form of seeps and artesian flow from wells, the former caused by the intersection of the plume with the steep topographic slope of the valley and the latter caused by vertically-upward flow from confining conditions in bedrock at depth. Vertically-upward flow also has been observed in wells located in the eastern portions of the Site.
- Exhibits 6-8 through 6-12 were prepared superimposing surface and bedrock topography and water table elevations onto the plume maps. Exhibit 6-8 shows the plan view of the TCE plume in the shallow overburden till and surface topography with isocontours. Exhibit 6-9 shows the plan view of the TCE plume in the shallow overburden till and the water table surface, depicting the approximate groundwater flow direction and gradient. Exhibit 6-10 shows the plan view of the TCE plume in the weathered bedrock and underlying highly-fractured bedrock and surface topography with isocontours. Exhibit 6-11 shows the plan view of the TCE plume in weathered bedrock and underlying highly-fractured bedrock and the water table surface, depicting the approximate groundwater flow direction and gradient. Exhibit 6-12 shows the plan view of the TCE plume in the weathered bedrock and underlying highly fractured bedrock and the bedrock topography with isocontours.

As evident from these exhibits, TCE-contaminated groundwater is present within the unconsolidated till and within the bedrock (including weathered bedrock, highly-fractured bedrock and the less-fractured, competent bedrock lithologies). Plume presence appears to be a continuum within the till and these bedrock lithologies, i.e., there do not appear to be different aquifers or hydrostratigraphic units separated by aquitards or aquitards-like conditions. However, the nature and quantitative characteristics of groundwater flow varies due to the naturally variable differences in the hydrogeologic properties of the till and the bedrock lithologies, and thus contaminant migration and/or attenuation will vary at different locations accordingly

6.2 Conceptual Site Model Summary

The following is a summary of the CSM for the Site, which synthesizes the known information and new findings generated during the RI effort.

6.2.1 General Physiographic and Ecological Setting

The FWEC/Church Road TCE Site (Site) is located in Mountain Top, Wright Township, Luzerne County, Pennsylvania. Regionally, ground surface elevations rise to the east of the former FWEC Facility property and generally slope downward to the north, west, and south. Immediately west of the northern portion of the former FWEC Facility and localized to this area, ground surface slopes upward to a plateau-like ridge occupied by the Philips Lighting Facility property. Ground surface slopes radially from the Philips Lighting Facility, consistent with the regional topography. In the SIPs, localized ground topography is significantly impacted by the industrial development. In general, south and west of the former FWEC Facility, ground surface elevations slope to the south and west toward the Affected Area, with decreases in elevation from approximately 1,620 feet msl at the former FWEC Facility to approximately 1,300 feet msl at the downgradient edge of the Affected Area.

The former FWEC Facility is covered by large former building cement slabs, asphalt and gravel parking lots and access roads and open field areas formerly used as storage areas. A former WWTP also is present and covers an area of approximately 0.16 acres. While evidence of wildlife occurrence on the former FWEC Facility was observed, the lack of significant habitat present in the developed portion of the former FWEC Facility limits its value for supporting significant populations of ecological receptors. The former WWTP does afford limited habitat value as open water, though its small size and potential intermittent nature substantially limit its capacity to support a permanent aquatic community.

The Affected Area is approximately 295 acres of mixed land use centered along the main channel of Watering Run, the primary surface water feature in the Site area. This area consists of riparian, wetland and open water habitats of Watering Run. Tributaries and groundwater seeps and springs discharge along the channel course. The riparian and wetland habitats present include upland broadleaf deciduous forests, low land broadleaf deciduous forests, emergent wetland areas and ephemeral springs. The open water channel of Watering Run originates on the former FWEC Facility and flows downgradient, converging with multiple tributaries and ephemeral springs along the length of the Affected Area. The aquatic, riparian and terrestrial habitats present within the Affected Area represent the most significant habitats present at the Site.

The SIPs also occur adjacent to the channel of Watering Run and downstream of the former FWEC Facility. The SIP area consists of multiple industrial and commercial properties with associated impervious asphalt parking areas, mowed lawn and landscaping features. The developed nature of the SIPs does not afford significant value as wildlife habitat. The only exceptions are isolated, fragmented or adjacent forested areas present on the properties associated with the forested corridor of Watering Run.

6.2.2 Geology, Hydrogeology and Surface Water Hydrology

The local geology is comprised of two primary stratigraphic units – overburden and bedrock. The overburden consists of unconsolidated glacial till with minor occurrences of fill in the SIP area. The till is underlain by two types of incompetent bedrock – weathered bedrock underlain by highly-fractured bedrock. Less fractured, competent bedrock underlies the incompetent bedrock.

Groundwater flow direction on and near the former FWEC Facility is generally to the south-southwest and, at more distal locations from the Facility, in the Affected Area, groundwater flow direction is generally to the west. A groundwater elevation high is consistently observed in the southeast corner of the CertainTeed facility, resulting in a localized occurrence of northwesterly groundwater flow which also influences the primary groundwater flow direction to the west down the valley. Groundwater flowing southwesterly from the former FWEC Facility through some of the SIPs is directed into a more westerly flow direction by the northwesterly flow gradient caused by the localized groundwater elevation high. Groundwater flow south of the former FWEC Facility, in the area of the CertainTeed and Bergen Machine facilities, might be migrating locally in a northerly direction onto the former FWEC Facility property as a result of groundwater gradients induced by the currently operating GETS.

Although regional studies indicate that bedding plane orientation controls groundwater flow, site specific data indicates that the primary controlling factors dictating groundwater flow direction in the Affected Area are the overall shape of the valley, the presence of Watering Run (as a local groundwater discharge point), and the top of the bedrock surface. Rainfall variation appears to influence the groundwater flow direction on portions of the former FWEC Facility and has a less pronounced effect on off-property areas where the valley shape and bedrock configuration constrain groundwater flow more consistently. The presence of the perennial gaining stream (Watering Run) along the valley floor also helps to channel groundwater flow along the topographic contours of the valley. At a large scale, geologic structure (i.e., bedding and fracture planes) does not appear to have a significant controlling influence on groundwater flow. Groundwater flow is affected by changes in hydraulic head and geologic heterogeneity, resulting in local variability in vertically downward and upward flow gradients, as well as steeper gradients in the eastern portions of the Site and less steep gradients in the western portions of the site.

While the macro-scale distribution of hydraulic head has a net flow direction from the former FWEC Facility to the western margin of the Affected Area, locally, vertical hydraulic head gradients are complex and appear to be caused by the combined influences of the primary groundwater flow direction, extraction well operation at the former FWEC Facility and localized artesian conditions. Groundwater in bedrock at depth may be under confined or semi-confined conditions in the eastern part of the Affected Area.

Flow within the till is influenced by unconsolidated deposit heterogeneity, with some degree of preferential flow as a function of the differences in hydraulic conductivity that naturally exist as a function of this heterogeneity. Flow within the weathered bedrock is likely to be variably influenced by the local degree of weathering, wherein flow would be dominated by former fractures (secondary porosity) enhanced by weathering. Flow within the highly-fractured bedrock and less-fractured, competent bedrock is likely to be dominated by fracture flow, with probable higher transmissivity conditions existing in the more highly-fractured bedrock.

The former FWEC Facility is located at a surface water drainage divide, with the northern portion of the property draining to the north towards Bow Creek and the central and southern portions of the property draining to the south towards the surface feature that drains into Watering Run.

6.2.3 Contaminant Presence, Fate and Transport

Sources of chlorinated solvent-related contamination, specifically TCE and, to a lesser extent 1,1,1-trichloroethane (1,1,1-TCA), remain on the former FWEC Facility. Spatial data evaluation also indicates potential TCE contaminant sources in the vicinity of the CertainTeed, Bergen Machine, and Fabri-Kal facilities. The combined sources result in a comingled plume of undefined confluence.

Groundwater with constituents above regulatory screening levels is present at the former FWEC Facility and in the Affected Area, as well as at the three SIPs mentioned above. VOCs with concentrations greater than screening criteria include TCE (the primary contaminant for the site); 1,1,1-TCA; 1,1,2-TCA; 1,1-DCA; 1,2-DCA; 1,1-DCE; acrolein; benzene; bromodichloromethane; carbon tetrachloride; chloroform; PCE; vinyl chloride; and 1,4-dioxane. Surface water and/or sediments in the former WWTP on the former FWEC Facility property, as well as in select areas within Watering Run and its associated tributaries, also contain constituents above regulatory screening levels.

The migration of constituents from impacted areas/soil matrices to groundwater, and then within groundwater following the local flow direction, is the principal environmental fate and transport mechanism for the Site. Subsequent upwelling of impacted groundwater into seep/spring areas, wetland and pond areas, and/or into Watering Run and tributaries also is an environmental fate and transport mechanism.

Site-wide, TCE in groundwater is present in a linear plume whose morphology is strongly influenced by regional and localized topography, bedrock structure, and localized variations in both horizontal and vertical hydraulic gradients. The plume originates at the former FWEC Facility, flows in a generally southwesterly direction, exhibits a pronounced directional shift in the vicinity of the CertainTeed facility, and flows westerly through the Affected Area to the western portion of the Site. In certain areas of the Affected Area, the plume manifests itself at the surface in the forms of seeps and artesian flow from monitoring wells. The plume exhibits a higher-concentration plume core throughout its length, indicating that migration is predominantly via advective transport with relatively limited lateral dispersion.

TCE-contaminated groundwater is present within unconsolidated till and bedrock, including weathered bedrock, highly-fractured bedrock and less-fractured, competent bedrock lithologies. In the till, areas of contamination of approximately equivalent concentrations are present at the CertainTeed and Bergen Machine facilities, and at the Fabri-Kal facility. A significantly larger area of contamination within the till is located further downgradient near the western boundary of the Affected Area. In the bedrock, areas of contamination are present predominantly at the former FWEC Facility, at the CertainTeed and Bergen Machine facilities, and in the Affected Area.

The plume appears to be continuous within both the till and all bedrock lithologies, i.e., there do not appear to be distinct or isolated aquifers or hydrostratigraphic units separated by aquitards or aquitard-like conditions. However, the nature and quantitative characteristics of groundwater flow likely varies due to the naturally variable differences in the hydrogeologic properties of the till and the bedrock lithologies. As a result, contaminant migration and/or attenuation at different locations will vary accordingly.

Flow within the till is likely to correspond to unconsolidated deposit heterogeneity, with some degree of preferential flow as a function of the differences in hydraulic conductivity that naturally exist as function of this heterogeneity. Flow within the weathered bedrock is variably influenced by the local degree of weathering, wherein flow would be dominated by historic fractures (secondary porosity) enhanced by weathering. Flow within the highly-fractured bedrock and less-fractured, competent bedrock is likely to be dominated by fracture flow, with probable higher transmissivity conditions existing within the more highly-fractured bedrock. Some degree of attenuation via contaminant diffusion into the weathered matrix (primary porosity) is also likely. A matrix diffusion investigation conducted on bedrock cores collected in the vicinity of the former vapor degreaser on the former FWEC Facility indicates that contaminants have diffused into the primary porosity (bedrock matrix) of the fractured, porous sedimentary bedrock.

Based upon the local groundwater flow direction, generally south-southwest to west, and groundwater quality data, constituents in groundwater originating from the various suspected potential source areas at the former FWEC Facility, and in the vicinity of the CertainTeed, Bergen Machine, and Fabri-Kal facilities, have migrated, and will continue to migrate until dilution and removal mechanisms such as adsorption, degradation, precipitation, and limited volatilization result in their eventual non-detection and/or until the impacted groundwater discharges to the seeps/springs and/or Watering Run. Vertically, groundwater data also show site-related constituents have migrated to and within the bedrock via fracture flow to depths greater than 300 feet bgs, with concentrations significantly decreasing with increasing depth. Based upon physicochemical characteristics, VOCs and dissolved metals would be expected to migrate the farthest in groundwater, while other organic constituents and metals associated with fine particulates are expected to migrate with the groundwater flow for only a limited distance.

Groundwater data collected during the RI field investigation indicate that the operation of the on-site GETS, along with natural fate/transport mechanisms, has resulted in a decline in constituent concentration levels present at the former FWEC Facility, including the concentration of TCE. Natural fate/transport processes are also gradually reducing constituent concentrations within the Affected Area, where the data indicate a decline in TCE concentrations. Constituents in groundwater originating from the former FWEC Facility and potentially from the three SIPs noted above have migrated to the Affected Area and will persist until dilution, degradation, and removal by the GETS result in their eventual non-detection or until the impacted groundwater discharges to surficial seeps, springs or Watering Run.

In contrast to the declining trends at the former FWEC Facility and the Affected Area, concentrations of TCE detected in monitoring wells proximate to the three above-mentioned SIPs do not appear to have declined in magnitude between historic and more recent sampling events, which may also indicate the potential for additional, localized sources in the vicinity of the CertainTeed, Bergen Machine and Fabri-Kal facilities.

7.0 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

The following sections summarize the overall conclusions of the Baseline Human Health Risk Assessment (BHHRA) and the Screening Level Ecological Risk Assessment (SLERA). The complete BHHRA and SLERA are provided in Appendices M and L, respectively.

7.1 Human Health Risk Assessment

A BHHRA was performed in accordance with CERCLA and the USEPA-approved RI/FS Work Plan and is provided in Appendix M to this RI Report. Potential health risks above target thresholds were identified for the former FWEC Facility with respect to potential future exposures to:

- TCE in groundwater that is hypothetically consumed by a potential future commercial worker;
- TCE in the soil that is directly contacted by a potential future commercial worker;
- TCE and several other volatile contaminants in indoor air inhaled by a potential future commercial worker conducting activities in an on-site building impacted by volatiles released from contaminated groundwater (assuming appropriate mitigation measures were not incorporated into the new structure);
- TCE in shallow groundwater that could be directly contacted by a potential future construction/utility worker;
- TCE in the soil by a potential future construction/utility worker (especially in the MIP1 Area);
- TCE, other volatiles and some inorganics in the soil and groundwater (if used for domestic supply) by hypothetical future child and adult residents; and
- Carcinogenic PAHs in the wastewater treatment retention pond (WWTP) sediment that could be directly contacted by a hypothetical future child resident.

The analysis also showed that if a current trespasser were to spend all of his/her time in the MIP1 Area and be exposed only to the surface soil there (in contrast to accessing and contacting the surface soil over the entire former FWEC Facility) exposure to TCE in the soil would lead to projected non-cancer risks above the target threshold.

No current health risks were identified for the Affected Area residences so long as the shallow groundwater is not used as a drinking water supply. The use of shallow groundwater as a drinking water supply has effectively been precluded by the connection of virtually every residence to the municipal water system, as well as by deed restrictions prohibiting the use of groundwater on nearly all of the properties within the Affected Area. At one residence, where connection to the municipal water system was refused, the installation of a point of use groundwater treatment system mitigates this potential risk.

A comprehensive VI evaluation also was performed at the residences and public buildings within the Affected Area that were identified in the Work Plan as having the greatest potential for VI, based on an assessment of the distribution and measured concentrations of TCE in the groundwater beneath the Affected Area at that time. Sampling of certain combinations of the shallow groundwater, sub-slab vapor or soil gas from beyond the building foundation, and indoor and outdoor air was performed on a location-specific basis to support the VI investigation as described in the Work Plan. The RI sampling results at each sampled location were collectively evaluated using a three-step tiered process to determine whether the measured indoor air contaminant levels of any volatile constituents could be due to VI from the underlying groundwater and whether those constituents were present at levels that might pose an inhalation risk above conservative regulatory risk-based thresholds. The VI investigation approach that was employed had been reviewed and approved by USEPA prior to implementation. This evaluation considered multiple lines of evidence and concluded that the levels of TCE measured in the various environmental media in 2010 could pose an unacceptable human health inhalation risk at only two particular residences associated with unique hydrogeologic and/or subsurface conditions (i.e., residential construction on the site of a natural spring and a leaking former well pump flooding the material beneath the foundation slab of another residence) could pose an unacceptable human health inhalation risk due to VI. However, active soil depressurization (ASD) systems were installed at both of these residences (i.e., Location 11 at 175 Church Road and Location 16 at 194 Church Road) in 2011 following the 2010 sampling and analyses to mitigate this potential inhalation risk. Operation of these mitigation systems effectively eliminates this potential exposure pathway at these locations. The data and VI analysis for the Affected Area did not indicate similar VI risk at other locations.

Based on approximately 10 years of groundwater data from groundwater monitoring wells and the VI investigation groundwater sampling, the extent of the contaminant plume in the Affected Area is stable and the contaminant concentrations have declined over time due to the continuing operation of the GETS at the former FWEC Facility and natural attenuation processes that are reducing the concentrations of many of the contaminants. In addition, the closure and cessation of pumping at the former private wells in the Affected Area has reduced the induced migration of groundwater toward the residences. This also has led to a reduction in the concentrations of volatile groundwater contaminants beneath the structures and a corresponding reduction in the potential VI at these locations. These ongoing activities and natural processes are expected to lead to further declines in the concentrations of the shallow VOC groundwater contaminants in the Affected Area, and a further reduction in the potential for VI at these locations in the future. Based on the downward trend in contaminant concentrations and the installation and operation of the VI mitigation systems at the two residences associated the unique subsurface conditions that increased the localized potential for VI, the current VI health risks via the indoor air exposure pathway for the Affected Area have been mitigated. However, a potential future VI risk will remain as long as the groundwater in the Affected Area is impacted by volatile organic compounds.

Two potential health risks were identified for the SIPs PEA relative to the local groundwater. The first was associated with the hypothetical consumptive use of the groundwater (i.e., used for drinking water and/or general commercial or residential use). However, these potential exposures are unlikely to occur because these businesses also are connected to the municipal water supply and the local groundwater is not used now, or is it likely to be used for those purposes in the future. The second highlighted potential risk was associated with the possible direct contact exposure to TCE in the shallow groundwater by a future construction/utility worker performing excavation on one of the properties impacted by the TCE plume at a location where the depth to impacted groundwater was relatively shallow.

The USEPA-approved RI/FS Work Plan did not require a targeted VI investigation for the SIPs. As a result, the data collected during the RI investigations, which included data relevant to the assessment of potential health risk relative to VI at the SIPs where TCE has been detected in the groundwater, was insufficient to perform a conclusive quantitative VI analysis for those SIPs. Based on the data collected during the RI investigation, structures associated with three particular SIPs (i.e., Bergen Machine, Certain Teed Corporation and, possibly, Fabri-Kal) may be located within 100 feet of the TCE groundwater plume migrating from the former FWEC Facility rather than being affected by localized sources.

No current health risks were identified for individuals currently accessing the Watering Run PEA. However, there is the potential for direct contact exposure and risk to manganese in the sediments by a future construction worker if:

1. an extensive construction or re-development project were to be undertaken along Watering Run that would both require the most impacted sediments to be handled for an extended period of time; and
2. the construction workers would not use common personal protective equipment or implement routine best practices to limit exposure to the impacted sediments.

The potential risks in this scenario are primarily associated with exposure to manganese in the sediment, not TCE. These potential exposures could be limited by institutional controls or other measures to minimize exposure during a future construction or redevelopment project.

7.2 Screening Level Ecological Risk Assessment

A SLERA was performed to conservatively assess the potential exposure and risks to terrestrial and aquatic ecological receptors. Environmental media evaluated as part of the SLERA included surface soils, surface water, surface sediments, and pore water. Results of the initial and refined screening evaluation determined that low level concentrations of TCE and other chemical constituents in the surface water and sediments associated with the seeps/springs did not pose a significant risk to aquatic life or amphibians in these environments. Select metals were found to exceed benthic community benchmarks for community diversity or structure. These PEC exceedances were noted at SD06 and SD19 for manganese and iron at both stations within Watering Run. In addition, benthic risks at SD19 were also associated with nickel and zinc at SD19. The lack of corresponding background metals data for Watering Run prevented the assessment of variation in metals to better assess the significance of these exceedances relative to local conditions. Therefore, some uncertainty exists in the risk characterization due to the lack of background data for these metals for local conditions.

Sediments and surface water in the former WWTP contained COPECs, including PAHs, pesticides, PCBs and heavy metals that exceeded corresponding Ambient Water Quality Criteria (AWQC) and Sediment Quality Guidelines (SQG). A potential risk to pelagic organisms and benthic macro-invertebrates in the pond environment was identified, and the above suites of constituents were retained as COPECs for the WWTP.

Screening of surface soils data revealed that select PAHs present in the former Shot Blast Area and Expended Waste Area exceeded receptor specific ecological soil screening levels (Eco-SSLs) for terrestrial plants, soil invertebrates and wildlife receptors, such as mammals and birds. Potential risks of PAHs to avian receptors could not be initially assessed due to the absence of a corresponding Eco-SSL for this receptor group. Risks to these receptor groups were determined to be low in the former Open Area West of the Main Building.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The RI activities confirmed much of the prior understanding of the Site and surrounding area, including, but not limited to:

- The locations and extent of residual source areas on the former FWEC Facility;
- Geologic and hydrogeologic conditions, including the prevailing groundwater flow directions;
- The horizontal extent of impacted groundwater in the Affected Area (i.e., the boundaries of the plume are not expanding); and
- The absence of current VI concerns in the Affected Area, based on the direct evaluation of the measured conditions or the installation of VI mitigation systems at two residences with subsurface conditions that promoted localized VI migration.

Data collected during the RI have further demonstrated that:

- The concentrations of TCE in groundwater on the former FWEC Facility are declining due to the ongoing operation of the GETS and natural attenuation processes;
- The concentrations of TCE in groundwater in the Affected Area are declining as a result of natural attenuation processes and the operation of the GETS at the former FWEC Facility;
- Spatial data evaluation indicates potential TCE contaminant sources in the vicinity of the CertainTeed, Bergen Machine, and Fabri-Kal facilities. TCE from these potential sources would migrate into the Affected Area; and
- The concentrations of TCE in groundwater located proximate to the three above-mentioned SIPs do not appear to have declined in magnitude between the historic and more recent sampling events.

Based on the data analyses and risk assessment performed pursuant to the RI/FS Work Plan, there are no current human health risks, and there are no threats to ecological receptors that require or warrant immediate action. However, the potential for some future risks to Site users were identified if construction activities or redevelopment were to occur.

More specifically, if an extensive construction project were undertaken at the former FWEC Facility that results in handling of impacted soil or contact with groundwater in a trench and the construction workers failed to use common personal protective equipment or implement routine best practices, exposure to TCE in groundwater and TCE in MIP 1 soils could result in an unacceptable risk. Similarly, construction activity in the SIPs resulting in extensive contact with groundwater in a trench could result in an unacceptable risk due to TCE in groundwater in the absence of appropriate health and safety practices. Likewise, if construction activity were to involve extensive contact with the most contaminated Watering Run sediments, exposure to manganese in the sediments could result in an unacceptable risk in the absence of appropriate health and safety practices.

Unacceptable risks were identified for a number of hypothetical exposure scenarios, including those resulting from vapor intrusion from groundwater into a hypothetical future building at the Former FWEC Facility, assuming no vapor mitigation is incorporated into the construction of the new structure. Unacceptable risks were identified for hypothetical domestic use of groundwater at the Former FWEC Facility, the Affected Area, and the SIPs. Unacceptable risks also were identified for hypothetical use of groundwater in the workplace by a commercial worker (e.g., drinking water, sanitary supply). However, these hypothetical exposure pathways have effectively been precluded by the connection of virtually every residence and business to the municipal water system, as well as by deed restrictions prohibiting the use of groundwater by nearly all of the property owners in the Affected Area.

In addition, the potential for future risks associated with the groundwater in the Affected Area will remain as long as the groundwater is impacted by volatile organic compounds and residual contamination remains in the environmental media at the former FWEC Facility. The impacted media at the Site and associated migration pathways to other PEAs associated with potential future risks to human health have been sufficiently delineated to proceed to performance of the Feasibility Study for the Site, which will identify and evaluate potential remedial actions that might be appropriate to implement at the Site.

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